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ABSTRACT

The development of the concept of an offshore deepwater crude oil terminal is reviewed with emphasis placed on current proposals. A general examination of the Federal Dredging program is made concentrating on the problems of the recent past. Projections of the demand for navigational dredging are analyzed through 1983 for their impact upon the nation. The need for national and/or regional alternatives to increased dredging is affirmed. An analysis of the ocean-going commerce of the Gulf Coast region is performed and principal commodities are identified. A conceptual design of an offshore petroleum product terminal is presented and the economic worth of such a concept is explored. The effect of a reduction in Federally authorized dredging depths is examined when accomplished in consort with the construction of offshore terminals. Conclusions are drawn and recommendations made pertaining to the desirability of the construction of offshore cargo terminals as alternatives to the increased dredging of the nation's waterways.

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CHAPTER 1

U. S. DEEPWATER PORT DEVELOPMENT

1.0 Introduction

On January 3, 1975 the Deepwater Port Act of 1974 (PL-93-627) was signed into law. The U. S. Coast Guard acting on behalf of the Secretary of the Department of Transportation (DOT) published the regulations for the implementation of this Act in November, 1975. (1) Shortly, thereafter the Coast Guard received applications for the construction and operation of two offshore deepwater crude oil terminals in the Gulf of Mexico. The Secretary of the DOT has been granted a maximum of 330 days in which to render a decision on the licensing of these terminals. This relatively fast-paced scenario of government events followed on the heels of no less than 6 years research by four departments of the Federal government, and numerous public and private agencies and councils. Several bills were debated in both houses of Congress for 2 years prior to the adoption of H. R. 10701 which was ultimately to become the Deepwater Port Act of 1974. A "deepwater port" for the purposes of this Act is a manmade terminal (other than a vessel) located outside the territorial sea (3 mile limit) of the U. S. for the express purpose of transferring crude oil and its products. The Act and its forthcoming regulations impose Federal control on the location, construction and operation of any such terminal. The basic need for and the desirable characteristics of an offshore deepwater oil port

have been discussed at length in no less than 10 major nationwide studies and a multitude of local area investigations. The intent of this chapter is to relay the current status of the development of deepwater ports in the U. S. The foregone conclusions of previous studies will not be reported in detail, however, References (2) through (14) may be consulted if one would desire to trace more closely the development of the concept. The need for a deepwater port has developed around the following circumstances.

1. The U. S. is presently and is expected to continue importing foreign crude oil in increasing volumes to fill the gap in rising demand and falling domestic production.
2. The carriage of crude oil in Very Large Crude Carrier (VLCC) tankships over long distances has exhibited significant economies of scale in transport costs.
3. The majority of the U. S. Ports are limited in depth to less than 45 ft. Tanker size is generally restricted by this depth limitation to 80,000 DWT.
4. Oil pollution of the nation's waters, tanker traffic and marine casualties are expected to increase significantly as a growing volume of crude oil is imported in tankships of less than 80,000 DWT.
5. Foreign transhipment facilities are presently operating that receive crude oil in VLCC tankships

and subsequently transfer this cargo to smaller tankers that serve U. S. ports. The growing dependency of the U. S. on these foreign facilities may prove less secure than if based on domestic facilities.

The concept of a U. S. port capable of directly receiving VLCC tankers able to transport 200K DWT to 400K DWT of crude oil has resulted from the above circumstances. The concept has been refined to consideration of an offshore facility in lieu of a coastal port to avoid the high cost of dredging required to attain water depths in excess of 60 ft. Additionally an inshore deepwater port would need comply with its state's Coastal Zone Management plan which might prove a time-consuming process. Timeliness of operation has been stressed in the Deepwater Port Act as a desirable characteristic for a concept. Finally strong environmental opposition to an inshore deepwater port has been met in areas where the required water depths occur naturally. The following advantages are attributed to offshore deepwater oil terminals:

1. Savings in the cost of transport of crude oil in a VLCC.
2. Reduction in the adverse environmental impacts associated with the importation of crude oil.
3. Reduction in the amount of tanker traffic on the nations waterways.
4. Reduction in potential dredging volume.

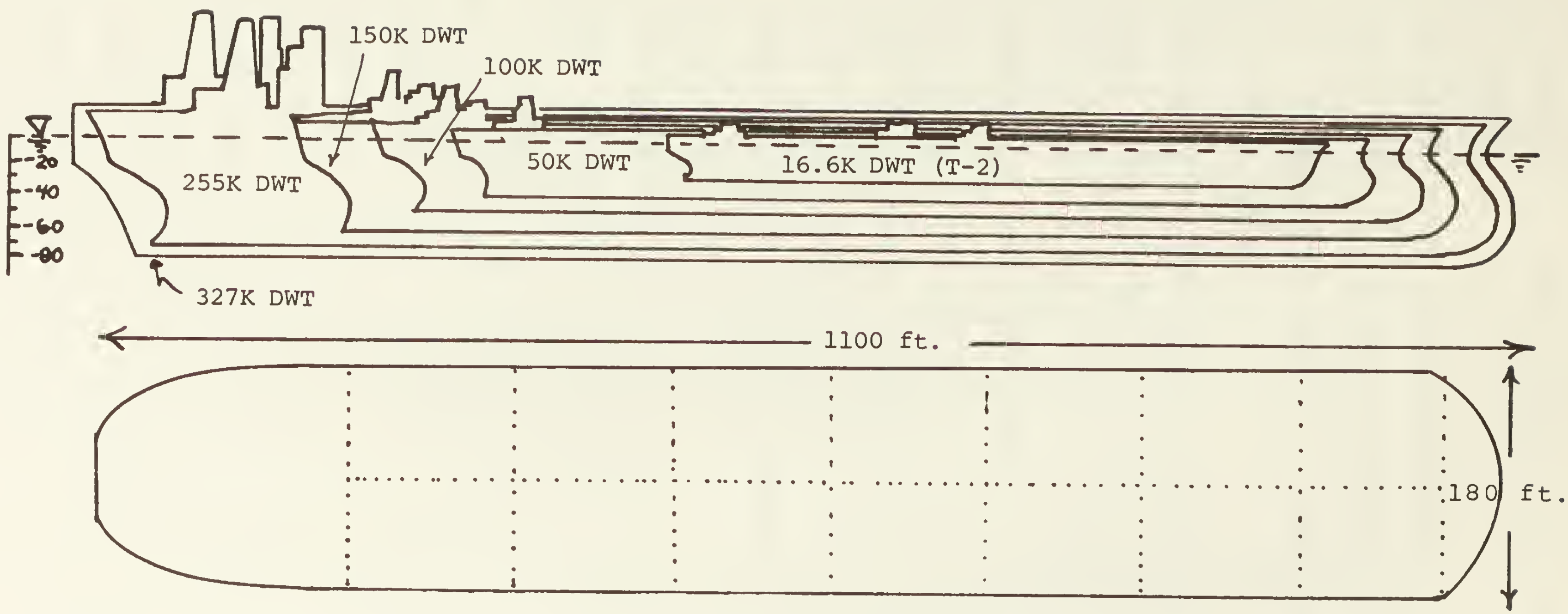
Reduced tanker traffic is a most apparent environmental advantage of an offshore deepwater port as a single voyage by a VLCC can replace 2 to 5 voyages of an 80K DWT tanker. The remaining advantages are worthy of note and will be discussed in the following sections.

1.1 Potential Advantages of Deepwater Ports

The Deepwater Port Act emphasizes the economies and environmental advantages of an offshore terminal. The sources of these advantages as well as the dredging requirements of a deepwater port will be briefly covered.

Transport Savings

Although some increased efficiency in the handling of crude oil through a single facility offshore in lieu of dozens of onshore facilities might be claimed, transport savings are derived from the use of VLCC. The term VLCC has been used to describe those tankers in the 200K DWT to 400K DWT range. Tankers of greater than 400K DWT are called Ultra Large Crude Carriers (ULCC). These vessel types developed in Japan in the mid-60's are the largest marine vehicles on earth. There were approximately 500 of these vessels operating in 1975 with another 75 on order or under construction.(15) The dimensions of a typical 250K DWT VLCC and a comparison of it with tankships is shown in Fig. 1.1. A most notable characteristic of these mammoth vessels in addition to their size is their relatively low ability to maneuver unaided in shallow or confined waters. A critical deepwater port design factor is the provision of adequate depth and maneuvering area to allow for the effects of adverse wave, current, and wind (when lightly



Oil Capacity	2,000,000 Barrels
Deadweight	272,000 Tons
Speed	14.5 Knots
Crew	41 Persons

Figure 1.1. Comparative Scale of Selected Tankers.
Source: The National Dredging Study (25)

loaded) conditions on a VLCC. Savings in the cost of transporting crude oil in these vessels have been possible for the following reasons:

1. The large scale and homogeneity of the design has been readily adapted to highly automated construction techniques leading to lower construction costs per ton of steel.
2. The scale of the design has also led to increased cargo density (tons of cargo/cu. ft of area) while maintaining a low weight fraction (tons structural steel/full load displacement). The resulting cost of construction per ton of cargo carried has been lower than that of conventional tankers.
3. Major design features have been carried over from lead-ship to follow-ship vessels further minimizing construction costs.
4. The operating costs of a VLCC have been minimized since crew size has been held relatively constant with that of conventional-size tankers.

An example of the relationship existing between vessel cargo carrying capacity (DWT), length of route and transportation costs is depicted in Figure 1.2. The rapidly changing slopes of the cost curves for all routes shown in tankers of less than 100K DWT give rise to the transport savings of the VLCC. The actual transportation cost of crude oil is dependent upon several factors including: vessel DWT, degree of loading, route length and the efficiency of loading and discharge

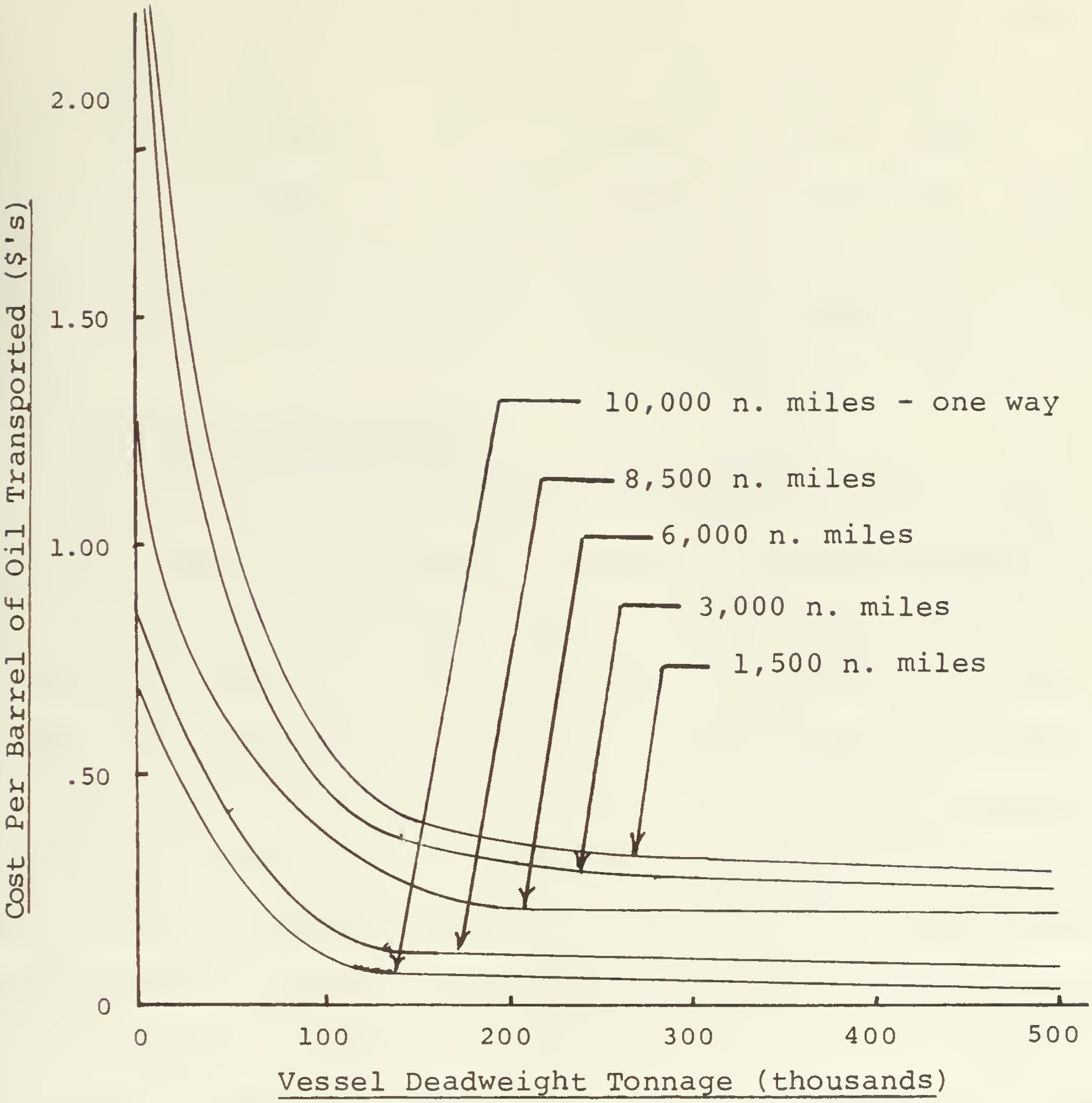


Figure 1.2. A Relationship Between Vessel Size, Transport Cost and Route Length. Source: Cooke, R., Modern Concepts . . . (29)

equipment as a reflection of turn-around-time. The transportation savings that may be claimed by any deepwater port concept in addition to the previous factors will depend on the base case for transport cost in conventional-size tankers. For the major deepwater port studies previously mentioned, transport savings under a variety of assumptions range from 25% to 50% of the base case transportation cost of crude oil imports.

Environmental Impacts

The Deepwater Port Act of 1974 requires of any applicant for the construction of such a facility, detailed information upon which an Environmental Impact Statement (EIS) may be prepared. Impacts upon the air, water, biosphere, land and water usage, economic and social structure must be assessed. The Coast Guard has recently issued the EIS for the Deepwater Port Regulations (16) and the Dept. of the Interior issued the EIS for the Deepwater Port Act in 1974. (12) The major adverse environmental impacts commonly associated with the importation of crude oil are oil spills, and harbor congestion and resulting marine casualties. The frequency of oil spillage has been directly related to the number of handling operations. (17) The frequency of oil spills may then be expected to decrease as less handling operations per year are required to transfer the same volume of oil from VLCC's through deepwater ports than from conventional-size tankers. The average volume per spill at a deepwater port has not been statistically justified. Deepwater ports, however, have claimed that the total volume of oil spilled will be reduced below the levels for conventional shipment. This claim is based around the belief

that a singular facility will provide increased protection against spills through flow monitoring devices and the on-site location of abatement equipment and trained personnel. A gross advantage of an offshore facility is its remote location from sensitive coastal zones and marshes. Distance from these environmentally critical areas is time in which oil containment measures may be taken. Additionally, the aromatic compounds in crude oil, the most lethal to the coastal biota, evaporate and dissolve rapidly with time which may be bought by increasing the distance offshore.

Dredging Requirements

An offshore deepwater port concept may be sited in a location where the depths required to receive VLCC tankers occur naturally. This is a distinct advantage that an off-shore port holds over an inshore site where in excess of 100 million cubic yards of sediment might need to be removed. The first cost (1975) estimates for deepening Corpus Christi Harbor (at Harbor Island) and Galveston Harbor, Texas to depths approaching 100 ft. have ranged from \$0.2B to \$1.5B, respectively. Annual maintenance dredging costs (1975) are estimated as exceeding \$1.0M each year thereafter. (18) Deepening of inshore harbor channels on such a large scale raises many environmental questions and may adversely affect current flow and patterns, salinity gradients, fresh water tables and the position of the inshore brackish water line. Many if not the majority of these effects as well as the costs of dredging may be avoided with the proper site selection of an offshore deepwater port.

1.2 Deepwater Port Technology

The concept of a deepwater port is not new; there are

presently in excess of 100 major ports worldwide capable of receiving tankers in excess of 200K DWT. (15) By contrast, the U. S., the largest oil consuming and refining nation in the world, has only two port areas (Puget Sound and Los Angeles/ Long Beach) capable of receiving tankers in excess of 100K DWT. The offshore deepwater transfer facility design is varied, the following concepts have been developed or planned:

1. Conventional Mooring Buoy (CMB): consists of a submerged pipeline from shore to the required depth contour and ending in a section of floating hose. The floating hose location is marked by a buoy. A VLCC will approach the marker buoy, anchor and moor in a fixed heading to several mooring buoys. The floating hose section may then be retrieved by a launch and connected to the vessels' manifold to begin transfer.
2. Single Point Mooring (SPM): consists of a submarine pipeline from shore or a pumping platform to the base of a floating buoy structure. The buoy structure may be stationed by one or several anchors. A floating section of transfer hose is attached to the buoy structure. A vessel will approach and moor directly to the buoy around which it may swing in an unrestricted arc as determined by wind and current conditions. A launch is used to retrieve the floating hose and transfer is accomplished as with the CMB.
3. Fixed Pier: consists of transfer platform permanently attached to the seabed by pilings. A vessel would

approach and moor to such a facility with the assistance of tug boats. Transfer is accomplished through metallic extendable "loading arms" which generally are designed for speedy coupling and decoupling. Such a platform may be provided with pumping, and ballasting capabilities. Due to the permanent orientation of the platform, designs which have been proposed for unsheltered areas sometimes have included provisions for a breakwater for protection from changing currents and waves.

4. <u>Jetty Pier</u>: consists of a transfer platform of similar structure and capabilities as the Fixed Pier. Storage capacity is not provided at the platform. The platform is directly connected to shore facilities by an above water access and therefore is most suitable in areas when required depths are adjacent to the shore line. Breakwaters have also been included with some designs.

5. <u>Floating Pier</u>: consisting of a floating or semi-submersible transfer platform fixed in position by anchors or retractable legs. This concept offers the advantage or mobility and onshore construction. Mooring is direct to the platform and transfer may be accomplished through loading arms. A limited ability to adjust the heading of the platform to prevailing wind and current conditions is also offered. A variation of this concept has been proposed to anchor the platform by means of piling or strut only

at one point. The platform would then be free to adjust its heading by swinging around the anchor point. A limited storage capability has been proposed with a semi-submersible platform and pumping and ballast capabilities are possible.

6. Artificial Sea Island: consists of a mooring, storage and transfer facility constructed at sea. A retaining wall would be constructed in a perimeter and then filled with material to form a permanent seawall or island. Vessels would moor on the outer perimeter of a sea island or on the inner perimeter of a seawall. A significant amount of storage capacity is included in most designs. Some concepts have included a breakwater in the design to create an atoll effect.

A subjective comparison of the foregoing offshore deepwater port concepts is provided in Table 1.1. A quantitative comparison of these concepts was normally conducted in the major studies previously referenced. Meaningful results from a detailed comparison are dependent upon local design factors and assumptions. The total cost of an offshore platform would include the costs of storage and the transhipment link between the platform and the distribution system. Table 1.1 includes only a comparison of platform costs. Detailed cost estimates for the two proposed U. S. deepwater ports will be discussed in a later section. A judgment as to the operating restrictions that each platform concept might face due to the adverse effects of wind and current conditions has also been made. Experience at existing facilities has indicated that limits for

TABLE 1.1

COMPARISON OF DEEPWATER TERMINAL CONCEPTS

	SPM	FIXED PIER	JETTY PIER	ARTIFICIAL ISLAND	FLOATING PIER	CBM
Initial Cost	Low	Low	Moderate	High	Moderate	Low
Mooring Assistance	Launch	Tug	Tug	Tug	Launch	Launch
Restrictive Mooring	Moderate	High w/o Breakwater	High w/o Breakwater	Low	Moderate	High
Ability To Handle Multiple Products	Limited	Yes	Yes	Yes	Yes	No
Construction Timing	Low	Moderate	Moderate	High	Moderate	Low
Reliability	Moderate	Moderate w/o Breakwater	Moderate w/o Breakwater	High	Moderate	Low
Offshore Storage Capability	No	Yes	No	Yes	Limited	No
Transshipment Links	Pipeline	Pipeline,Barge Tanker	Pipeline,Barge Tanker	Pipeline, Barge, Tanker	Pipeline, Barge, Tanker	Pipeline

specific combinations of wind and current will restrict the mooring, transfer, and departure phases of an operation. (13) Those concepts which are free to seek a new heading in changing weather and current conditions are less sensitive to these restrictions. The judgment concerning the overall reliability of a concept entails restrictions on operations due to weather, night-time operations as well as time lost for maintenance. The compatibility of each concept with pipeline, barge and conventional tanker transhipment links is also shown.

1.3 Current Proposals

Some 25 different deepwater port facilities have been proposed since 1970 for operation in the continental U. S. These proposals have included a variety of platform designs with costs (1974) ranging from $5M to $800M. Only two such concepts have progressed to the point where applications for the licensing of the facility have been submitted to the D.O.T. A description of these proposed facilities will be provided in this section. (18,19)

SEADOCK

SEADOCK, Inc. is a consortium of the following nine oil-related companies that have proposed the construction and operation of an offshore deepwater crude oil port in the vicinity of Freeport, Texas:

1. Cities Service Co.
2. Continental Pipeline Co.
3. Crown-Seadock Pipeline Corp.
4. Dow Chemical Co.
5. Exxon Pipeline Co.
6. Gulf Oil Corp.
7. Mobil Oil Corp.
8. Phillips Investment Co.
9. Shell Oil Co.

The facility is to be located 26 miles offshore from Freeport, Texas in 100 ft. of water in the Gulf of Mexico. The facility will be initially capable of receiving 1.6M barrels of crude oil per day (B/D) with an ultimate capacity of 2.0M to 3.0M B/D. Crude oil may be received from both VLCC and ULCC tankers in the range 300K DWT to 500K DWT. The initial construction cost (through 1980) of the proposal will be $659M with a final construction cost (1980) of $865M. The offshore marine facility will be composed of 4 SPM buoys (6 ultimately) each connected to an offshore pumping platform by a 52 in. O.D. submerged pipeline. The pumping platform will have a pumping capacity of approximately 100K barrels per hour. It will be connected to shore by 2 submarine pipelines (ultimately 3} of 52 in. O.D. and a 6 in. O.D. fuel line. An offshore personnel quarters platform will also be constructed. The offshore facility will be provided with communication, navigation, flow metering, and pollution containment equipment. Navigational traffic approach lanes and safety zones will be designed. An approaching tanker will be placed under the command of a docking pilot and master trained by the facility and licensed by the Coast Guard. All the offshore structures are to be designed to a 100-year storm criteria. This is a statistical method of estimating the wind, wave and current forces that might be exerted on these structures by the most severe storm to occur in a 100-year period.

The onshore terminal will be located approximately one-half mile inshore and consist of a tank farm, metering, pumping

and distribution equipment. Storage capacity initially has been designed for approximately 22.5M barrels (BBL) of crude oil. This may be expanded by 10M additional barrels if the terminal reaches ultimate capacity. The distribution network will be by onshore pipeline but will not be constructed by SEADOCK. It is anticipated that crude oil will be supplied to refineries operated by its members in Lake Charles, La., Beaumont/Port Arthur, Tx., and the Houston/Freeport/Galveston, Tx. areas. Facility operation is planned for 1980.

LOOP

Louisiana Offshore Oil Port (LOOP) Inc. is a consortium of the following oil-related member companies:

1. Amoco Oil Co.
2. Ashland Petroleum Co.
3. Clark O & R Corp.
4. ECOL LTD.
5. Exxon Co.
6. Koch Refining Co.
7. Marathon Oil Co.
8. Murphy Oil Corp.
9. Shell Oil Co.
10. Standard Oil Co. of Ohio
11. Tenneco Oil Co.
12. Texaco, Inc.
13. Union Oil of California

LOOP has proposed a crude oil deepwater terminal to be located some 18 miles offshore Bayou, LaFourche, La. This site is in the Gulf of Mexico in approximately 105 ft. of water. The ultimate capacity of this facility will be 3.0M B/D of crude oil serving tankers ranging up to 700K DWT. The initial construction cost (through 1980) of LOOP's offshore and onshore terminal is approximately $700M. The LOOP offshore marine facility is remarkedly similar to that of the SEADOCK proposal.

Three SPM buoys are planned initially with three being added later to obtain the ultimate capacity. The buoys and Pumping/ Operations platform will be connected by 56 in. O.D. submerged pipelines. Two submarine pipelines (ultimately 3) of a 48 in. O.D. will complete the transfer of oil to the onshore Fourchon booster station located approximately 3 miles from the coastline. The operation of the LOOP marine facility will follow the guidelines as described for SEADOCK. LOOP is investigating two alternatives for its onshore facility. Storage capacity will either be provided by a tank farm at the Fourchon station or in underground salt domes at Clovelly, La. The salt domes which would be hewn by pumping heated water into deposits some 1200 ft. below the surface are preferable to converting marsh land to a tank farm. The brine solution extracted from the salt excavation would be stored in a reservoir which would fill or empty as the flow of crude oil displaced it from the domes. Storage capacity of approximately 56M barrels is planned. A distribution system is also planned at a cost (through 1980) of $225M to link the storage facility with the CAPLINE crude oil terminal at St. James, La. CAPLINE is a major onshore crude oil distribution pipeline which runs from Louisiana to Illinois. Therefore, in addition to the Louisiana refining capacity along the Mississippi River, LOOP is expected to supply crude oil to refineries as far east as New York and in Illinois, Indiana, Ohio, and Kentucky. LOOP anticipates beginning operation in 1980.

The SPM concept was selected by both of these proposals for the following reasons:

1. Low initial cost.
2. Low construction impact on the surrounding environment.
3. Short construction period.
4. Tugs are not required for the mooring or departure operation.

It is of interest to note that neither of the foregoing proposals are strongly dependent upon major refinery expansion or construction within their respective market areas. The SEADOCK concept intends to just offset the decline in domestic oil production by meeting the demand for oil with foreign imports. Within the LOOP market area, only one "grass-roots" or new refinery (ECOL, La.) is planned for construction. The design to serve existing refinery capacity is unique to these concepts. Other deepwater port studies, particularly on the Eastern seaboard, have encountered a significant amount of environmental opposition for their requirement of a major expansion in refining capacity. The Coast Guard does not foresee any major obstacles in the approval of licenses for these proposals. (26) The SPM is a proven concept and has seen experience in over 100 worldwide locations over the past 15 years. (15) There are, however, areas of great economic uncertainty which raise the question if these facilities will actually be built by their sponsoring companies.

1.4 Uncertainties of Deepwater Ports

The economic success of an offshore deepwater port can be measured on two planes. On a national plane the success of such a venture might be measured in terms of the environmental benefits that this type facility might return to the nation.

Success or lack of it might also be gauged by the amount of transport savings that are accrued by U. S. concerns or passed on to the consumer as reflected in the price of petroleum products. A measurement of the environmental benefits such as a reduction in the volume of oil spilled might prove arbitrary at best and unquantifiable at worst. Potential transport savings offered by the concept to the U. S. economy might be absorbed in whole or part by any number of foreign interests concerned with the production, loading or transportation of crude oil. The OPEC cartel might foreseeably raise its tariff increasing the f.o.b. price of crude oil to negate any savings made possible by an offshore port. While such an occurrence was a real possibility in 1973 when those nations were supplying crude oil at near capacity, the probability has been diminished with most OPEC members now producing at only 60 to 80% of capacity. The national value of a deepwater port is lessened as the incidence of transport savings diminishes for U. S. companies or consumers.

A second plane upon which the success of a deepwater port can be measured is that of private enterprise. The incidence of transport savings could well fall upon U. S. oil-related companies. Additionally the tariffs charged by the port facilities themselves for the handling of crude oil will determine the return on investment to their owners. Revenues to the facilities will be wholly determined by the level of tariff and the flow of crude oil. It might be assumed that tariffs will be set (with I.C.C. approval) to "whatever the market will bear". To remain competitive suppliers, the

facilities must maintain the flow of crude oil at levels sufficient to generate acceptable revenues without resorting to highly inflated tariffs. The flow of crude oil through a deepwater port facility may be viewed as an uncertain function of the following variables:

1. U. S. demand for petroleum and its products through the year 2010 (i.e., life cycle of the proposed facilities).
2. U. S. production rates of petroleum and its products through the year 2010.
3. U. S. imports of foreign refined products through the year 2010.

Some rather basic subtraction of the foregoing variables will yield the amount of foreign crude to be imported. However, the variables themselves are total dependent upon numerous other factors. The demand for petroleum will be dependent upon Federal energy policy, the deregulation of natural gas, and the growth of nuclear plants, to name a few. The rate of U. S. production will be influenced by the price ceilings on domestic oil, the output of the Prudhoe Bay find, the results of the Georges Bank explorations and others. U. S. imports of foreign products may depend upon the expansion of refinery capacity in the OPEC nations, the resistance to "grass-roots" refineries in New England, and decisions of the Canadian government concerning petroleum exports. If a reasonable estimate of the demand for foreign crude oil can be made, the flow through a specific deepwater port still remains uncertain. Nearby sources

of foreign crude oil such as Venezula or Mexico, price cutting by foreign transhipment terminals, resistance of inshore domestic port facilities, the new dredging plans for the Suez Canal, insurance rates on VLCC tankers, etc. may all affect the source and size carrier of foreign crude oil and ultimately the flow through on offshore terminal.

It would appear that there is need for caution on the part of the nation as well as private industry in the pursuit of deepwater ports. There is also a greater need for continuous evaluation of the uncertainties as construction dates approach. The designs of both LOOP and SEADOCK have undergone revisions since their initial "pre-energy crisis" formulation. Design throughputs and vessel size have been reduced to reflect the recent period's decrease in the growth of petroleum demand.

The U. S. has traditionally dredged its coastal ports to accommodate the transport of waterborne commerce in deep-draft vessels. Recently the demand for dredging of the nation's waterways to ever deeper depths has been increasing. This demand may have serious economic and environmental effects on the nation as a whole. It is the purpose of this effort to investigate and evaluate alternatives to the future dredging of waterways now in commercial use. The practices and problems of the Federal Dredging Program will be described in Chapter 2. The demand for Federal dredging will be projected and evaluated through 1983 in Chapter 3. Prior to the formulation of alternatives, the cargo transport needs that dredging presently fulfills will be identified in Chapter 4. These needs will be evaluated

from a regional and national standpoint instead of on an individual port basis as has been past practice. The design of an alternative means to the transport of waterborne commerce on dredged waterways will be accomplished in Chapter 5. Emphasis will be placed on expanding the concept of offshore crude oil terminals that require no dredging. Conclusions will be drawn from this analysis and presented in Chapter 6.

CHAPTER 2

THE FEDERAL DREDGING PROGRAM

2.0 The U. S. Army Corps of Engineers

The inception of the U. S. Army Corps of Engineers was brought about by Act of Congress in 1779. With the passage of the Rivers and Harbors Act of 1824, the Corps was charged with the responsibility of the navigational control of the nation's rivers and harbors. Such was the beginning of the Federal Dredging Program. The responsibilities of the Corps in civil works water resource management have since been expanded by Congress to the following areas. (20)

1. Power development in navigation dams
2. Flood control
3. Recreational navigation
4. Recreation
5. Irrigation
6. Water supply
7. Shore and beach erosion protection
8. Hurricane protection
9. Water quality
10. Environmental emphasis
11. Commercial navigation

The Corps has divided its responsibilities for civil works projects into 11 major geographic Divisions and 38 Districts including all of the continental United States, Alaska, Hawaii

and the U. S. territories and possessions. Figure 2.1 depicts the Division and District boundaries of the Corps' area of responsibility in the continental U. S. In fulfillment of its navigational duties established in 1824, the Corps maintains more than 25,000 miles of inland and intracoastal waterways and in excess of 105 harbors now in commercial use. During Fiscal Year (FY) 1973 the total cost of these navigational projects was $264 million of which $168 million was devoted to dredging operations. (21) Dredging is the process by which sediments are mechanically removed from a waterway, transported to another location and disposed (as spoil) to land or returned to the water. The general purpose of dredging is to improve, extend and/or maintain a navigable waterway. Dredging may also be accomplished to obtain a construction material; however, dredging for navigational purpose will be stressed here. The three phases of a dredging operation will be briefly discussed in the following section.

2.1 The Dredging Process.

The removal, transport and disposal phases all possess unique elements which determine the overall cost and environmental impact of a dredging operation.

Sediment Removal - The method by which sediments are removed from a waterway is primarily determined by the consistency and volume of the material. However, equipment, local water, and traffic conditions, bottom contours, and the amount of polluting elements in the material may also influence the choice of a method. The consistency of sediment may vary by location in a

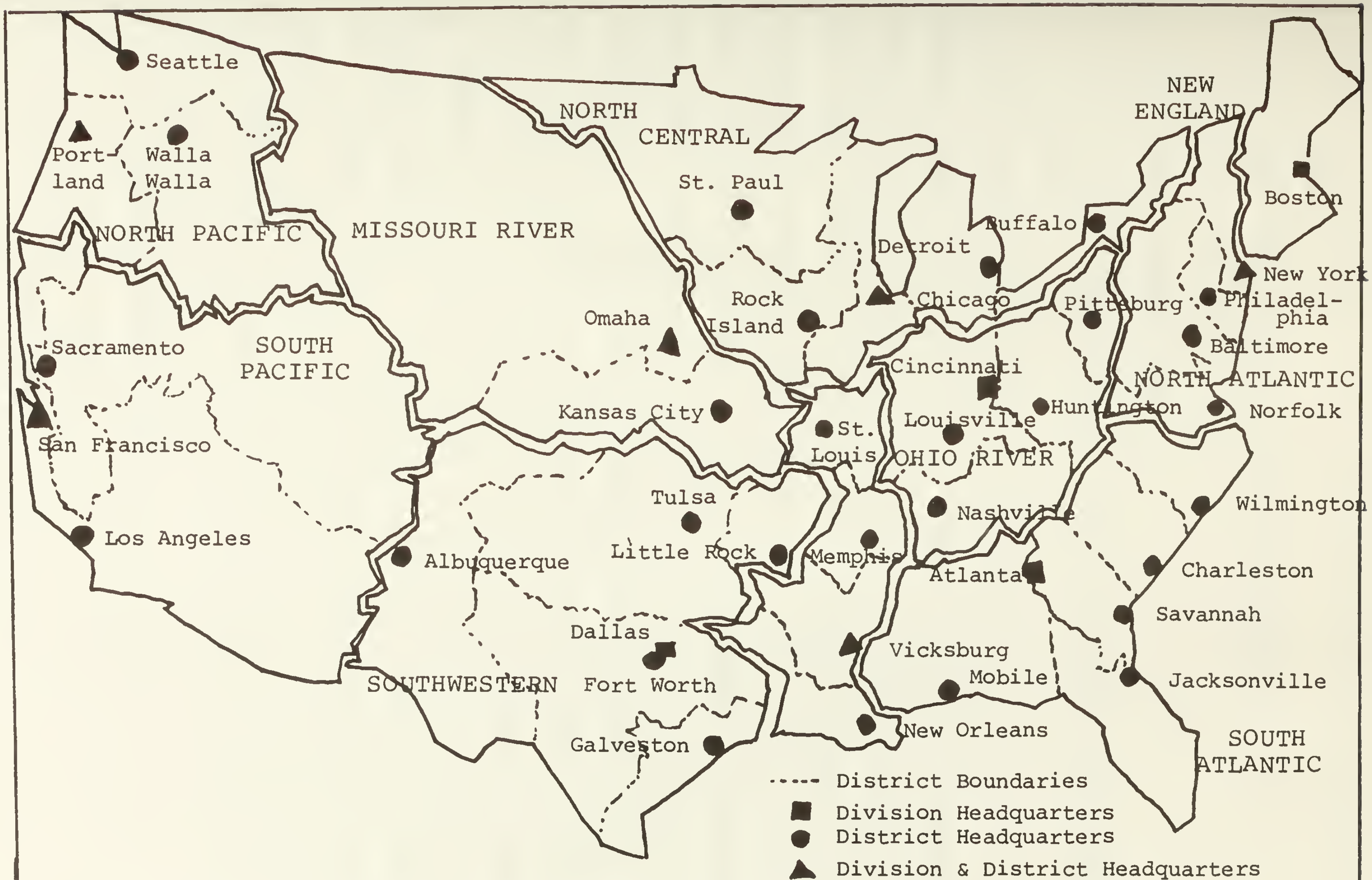


Figure 2.1. Geographic Divisions of the U.S. Army Corps of Engineers.
Source: USACOE, 1973 Annual Report ...(21)

waterway. Consistency is formally measured by grain size but has been associated with the following types of sediment. (22)

1. Rock
2. Mud, Clay, Silt, Topsoil, and Shale
3. Silt and Sand Mixed
4. Sand, Gravel and Shell
5. Organic muck, Sludge, Peat, Municipal and Industrial waste.
6. Mixtures

Sediment types 2, 3, 5, and 6 listed above pose removal and disposal problems as they are generally fine grained and mixed with large amounts of liquid. The removal of rock is generally preceded by underwater blasting which will not be treated as a separate removal method. The specific methods of sediment removal are based around hydraulic-mechanical or mechanical principles. The simplest hydraulic-mechanical means of dredging is the mechanical agitation of bottom sediments which are then removed by the current flow of the waterway. This method is commonly employed on some faster flowing reaches of the Mississippi River. A mechanical removal method is exemplified by a "dipper" dredge. This device uses a scooping motion similar to that of a steam shovel to trap sediment and bring it to the surface. Dredging equipment may be classified by its method of removal as follows:

1. Hydraulic-Mechanical:
    a. Hopper Dredge
    b. Dustpan Dredge

c. Sidecaster Dredge

d. Cutterhead Dredge

2. Mechanical:

a. Dipper Dredge

b. Clamshell Dredge

c. Bucket Dredge

d. Dragline Dredge

The cost of the removal phase of a dredging operation is directly related to the volume of material removed and the type of equipment utilized. Most costs of dredging are recorded in dollars per cubic yard ($/CY). The volume of material removed can be and is measured in a variety of ways. An accurate measurement of this volume is desirable as most costs are related to it. The primary method used by the Corps of Engineers is the conduct of pre and post dredging surveys. Comparisons of bottom depths between these two surveys permits the calculation of the amount of material removed. There are also several methods used to gauge bottom depths including: fathometer, lead line and rod. The fathometer method is preferred by all Corps' Districts. The results of a bottom survey for a section of waterway channel might appear as depicted in Figure 2.2. The Project Depth (PD) of a section of waterway is established by Congress in a River and Harbor bill. If enacted and signed into law, the Corps of Engineers becomes responsible for the construction and maintenance of that waterway to its Project Depth and to the width and length of channel specified. Project Depth must be distinguished from Controlling Depth (CD)

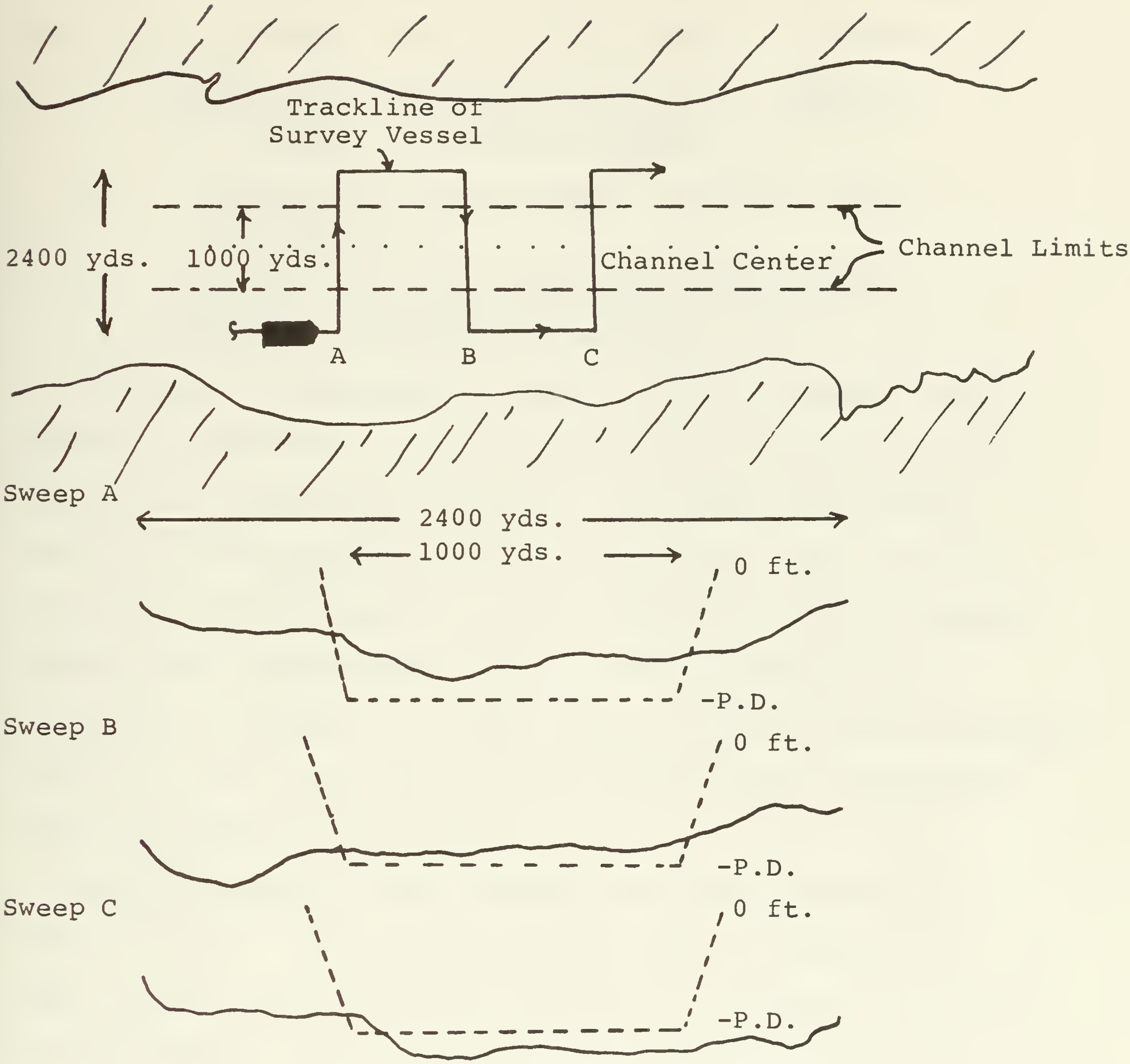


Figure 2.2. Sample Dredging Survey Results

which is the actual minimum channel depth over a section of waterway. A waterway's controlling depth may be less than, equal to, or greater than the Project Depth as follows:

1. CD less than PD-if the Corps has not completed dredging in a section of waterway for which a new or deeper PD has been approved.

2. CD equals PD-if the Corps has completed dredging to the specified PD.

3. CD greater than PD-if the Corps has completed dredging to the specified PD and deeper to accomplish "advance" maintainence.

The adverse environmental impacts of the sediment removal phase of dredging may entail increased water turbidity, disturbance of bottom dwelling benthic organisms and possible agitation and spreading of polluting agents. Once sediments have been removed changes in water velocity, current patterns and salinity gradients may occur to the detriment of the surrounding ecosystem. As with dredging costs, the environmental impact is also a function of volume and the type of equipment used and numerous other factors.

<u>Spoil Transport</u> - Once sediment has been removed it is termed "spoil". Spoil is transported from a dredging site for many reasons, the most basic of which is to prevent its return to the channel. Sand and gravel spoils may be transported to an area in need of construction materials as is done in beach nourishment operations. Many harbors have created new industry land sites through spoil management. Finally, dredged spoil may need to be transported at great distances to diked areas or to the open sea to prevent local water pollution by entrapped

contaminants. Transport may be accomplished in several ways as follows:

1. Current flow
2. Hydraulic pipeline
3. Marine carriers - scows, barges, hoppers, etc.
4. Land vehicles - trucks, railcar, etc.

The choice of a transport method is usually a function of the disposal method required. The transport cost of spoil is principally dependent upon volume and length of transit. The adverse environmental impacts of spoil transport are in general of minor concern when compared to the potential impacts of removal and disposal phases of dredging.

Spoil Disposal - Prior to 1972 approximately two-thirds of dredged spoil was directly returned to the water. (22) This method is referred to as "open-water" disposal. In 1972 with the passage of the Federal Water Pollution Control Act (FWPCA), the Environmental Protection Agency (EPA) imposed nationwide standards for "open-water" disposal of dredged spoil. These standards, developed from data gathered on the polluting qualities of the Great Lakes spoils, had a staggering effect on the dredging practices then followed by the Corps. A 1972 study conducted by the U. S. Army Engineer Waterways Experiment Station (22) estimated that no less than 31% of the Corps Annual maintenance dredging was "polluted" by the EPA standards. These spoils could not be returned to the adjacent waters. The following spoil disposal methods are now in use: (23)

1. Open Water - return of spoils to the water.
    a. Off Channel - spoil is returned to the waterway

within a realtively short distance of the removal site. This is the least expensive of all disposal methods and can be used to reclaim or construct landfalls and recreational areas. Short term turbidity usually is experienced at the discharge site. Additionally this method creates shoaling and may restrict the drainage of sensitive marsh areas.

b. Ocean or water body disposal - spoils are transported to the ocean or large water body areas at a distance from coastal zones for deposit. This method may become extremely expensive as the transit distance to and from the removal site grows. It is however preferable to the off-channel disposal of polluted spoils or to disposal in environmentally sensitive areas. This method may produce a cumulative adverse effect on the disposal site area.

2. Diked Disposal - placement of spoil behind artifically constructed dikes. When dikes may be located adjacent to the removal area this method shares many of the advantages of off-channel disposal. Additionaly, the contaminated run-off from polluted spoils may be controlled. Dikes constructed for this purpose may act as a flood control device. However, dikes must again be located in environmentally sensitive coastal zones. The costs of construction may be prohibitive in remote areas. Land aquisition costs have been found prohibitive in developed areas.

3. Upland Disposal - the disposal of spoil on existing land sites. This method also may be applied to land reclamation activities. However, the depths that spoil can be realistically "piled" are limited by a spoils' consistency. Twenty acres of land in West Haven, Ct. were required to dispose of 81,000 CY of dredged spoil. Again the cost of land in developed areas is often cost-prohibitive.

The 1972 EPA criteria were deficient in many areas. They lacked any guidelines for a sampling procedure. They ignored the fact that some standards were exceeded in areas where "polluted" elements occurred naturally. Further, they were solely based on the content of spoil and ignored the actual effects that disposed spoil might have on the surrounding environment. Consequently, by direction of Congress, the EPA jointly with the Corps of Engineers published in October 1973 a new set of guidelines for the ocean dumping of dredged spoil. More recently interim regulations have been published governing spoil disposal in inland areas. (24) The new guidelines focus on the effect that spoil will have on the disposal environment and provide a more realistic manner of identifying pollutants. Although it is too early to gauge the effect of the new guidelines, it is held that they will be less restrictive than the original criteria. (25)

2.2. Dredging Technology

In addition to issuing permits to allow private dredging, the Corps owns and maintains a fleet of dredging equipment. A

waterway dredging project with funds appropriated by Congress will either be accomplished by Corps-owned dredges under "Hired Labor" contracts, or by private industry dredges contracted for by the Corps. The equipment presently available to the Federal Dredging program consists of the following dredges:

1. Hopper: self-propelled sea-going dredge used principally in coastal zones and on the Great Lakes. These dredges are equipped with suction pumps and dragarms for the removal of sediment types 3, 4, and 5. Spoil is stored in hoppers aboard the dredge for a contained transit to the disposal site. The principal method of disposal is to the ocean and water bodies. However, some of these vessels have been modified for direct pump-out to upland disposal areas and for beach nourishment operations. The Corps presently owns and operates fifteen hopper dredges. Private industry is operating only one such dredge while three others are under construction. (26) These vessels are principally used in maintenance operations.

2. Hydraulic-Cutterhead: non self-propelled dredge used principally in protected and inland areas. The dredges are equipped with a revolving mechanical head of blades to loosen bottom sediments for removal through a hydraulic suction pipe. Sediments of types 2, 3, and 4 are normally removed

with this dredge. With special adaptation some soft rock may also be removed. Spoil transfer is accomplished through a pipeline to the disposal site. Open water and diked disposal methods are commonly used with this type of dredge. The Corps owns thirteen of these dredges; however, one was sunk in Savannah, Georgia in December, 1975. (26) These dredges are used for both maintenance and new construction work. It is estimated that there are in excess of 260 such dredges owned by private industry. (25)

3. Hydraulic Dustpan: self-propelled dredge specifically designed for operations on the Mississippi, Missouri, and Ohio River system. Equipped with a suction head not unlike a vacuum cleaner for the removal of loose sediments of types 3 and 4. Spoil is pumped via a floating pipeline to off-channel disposal sites. The Corps owns the entire U. S. fleet of dustpan dredges. There are 8 such dredges operational. This dredge is limited to maintenance work only.

4. Sidecaster: self-propelled sea going vessel used in the coastal zones in narrow inlets from the sea on the East Coast. These dredges are equipped with a suction pump and dragarm pulled astern for sediment types 3, 4, and 5. Spoil is transferred by relatively short pipelines (70-100 ft.) and deposited off-channel.

The Corps owns the entire fleet of three sidecasting dredges. The dredges are principally used for maintenance work.

5. Clamshell, Dipper, Bucket and Dragline: non-self-propelled dredges suited for confined areas in harbors and slips. These dredges are typically equipped with a scooping or grasping device that is barge mounted and suspended by wire. Sediment is removed and placed in a scow or barge for transport to a disposal area. These types of dredges are compatible with all disposal methods and all sediment types. Private industry owns all dredges of these types as follows: (25)

   Clamshell - 157
   Dipper - 13

   These dredges are used for both maintenance and new construction work.

The application of the foregoing equipment in the administration of the Federal Dredging Program has been changing with time. Some of the more recent problems that the Army Corps of Engineers has been experiencing with the program are described in the next section.

2.3 Problem Areas

The Federal Dredging Program as administered by the Corps of Engineers, has been wrestling with some unique problems over the past 5 years which are worthy of review. (23) In 1969 the National Environmental Policy Act (NEPA) required the preparation of an Environmental Impact Statement (EIS) for all major

Federal projects. The Corps at that time was responsible not only for the issuance of new dredging permits, but also for permits for the discharge of any polluting materials into the navigable waters. A heavy administrative burden resulted from the Act. The FWPCA and the Marine Protection Research and Sanctuaries Acts of 1972 extended the requirement for the preparation of an EIS to on-going maintenance dredging projects. Additionally, a 10-year moratorium was placed on the open-water disposal of "polluted" dredged spoils in the Great Lakes. The Corps was relieved of the responsibility of regulating the discharge of all contaminants except dredged spoils. These environmental restraints have been responsible for some of the increases in the cost of dredging over the past 3 years. Also, in 1972 a moratorium by the Congressional Public Works appropriations committees was placed on the Corps prohibiting the replacement of or major overhauls to the present Federal dredging fleet. This action was taken pending the outcome of The National Dredging Study conducted by A. D. Little, Inc. (25) The overall aim of this study, now complete, was to assess the present capabilities and future applications of the Federal Dredging program. The following are some of the more pertinent findings of this study:

1. Federally owned dredging equipment is generally old and past or approaching obsolescence.
    a. Hopper dredges require immediate and substantial replacement.
    b. Cutterhead dredges are generally obsolete.

c. Dustpan dredges require immediate upgrading to reduce operational and maintenance costs.

d. Sidecaster fleet should be expanded to reduce coverage areas.

2. Federally owned equipment is not sufficient to meet future demands.

3. Private contractors' dredging equipment is generally in good condition and sufficient to meet future demands.

4. Traditionally the Corps through Hired Labor contracts has performed approximately 90% of the dollar value of all maintenance dredging. While the larger share of new work has been performed under Contract to private industry.

5. The condition of the Federal dredging fleet reflects little of the current technology available to lessen the adverse environmental impacts encountered in the removal and disposal phases of dredging.

In the years 1972 through 1975 there has been a steady increase in the amount of maintenance dredging to be performed. This has placed a strain on an already aged and busy fleet of Federal equipment. The strain was particularly severe in the New Orleans district during this period where the Mississippi River system experienced some of the highest flood waters in the past 20 years. (27) In general the capability of the Federally-owned dredging fleet has been falling while demand for these services has been increasing in the recent past. A final problem area for the Corps and indeed the nation has been the erosion of its purchasing power by inflation. The shrinking

Federal Dredging budget will be covered in detail in the following chapter.

2.4 The Outlook For Solutions

The Corps of Engineers has taken several positive actions in search of some relief from the foregoing problem areas. In addition to the recently completed National Dredging Study, a 5-year study was initiated by the Army Engineer Waterways Experiment Station at Vicksburg, Mississippi. This study scheduled for completion in 1978 seeks to provide environmentally compatible solutions to the objectionable aspects of the removal and disposal phases of dredging. Of a more timely nature, the moratorium of Federal dredging equipment appropriations was lifted in February 1976. (26) An appropriation of $1.65M has been made for the construction of three new Hopper dredges by private industry.

The manner in which the Federal Dredging Program was applied has undergone several changes since 1970. The ability of this program to stand up to the demands of the future will be investigated in the following chapter.

CHAPTER 3

THE PROGNOSIS FOR DREDGING*

3.0 Federal Dredging Expenditures (1964-1973)

As suggested in the previous chapter, the Federal Dredging Program administered by the Army Corps of Engineers has undergone some trying challenges in the past five years. But, what of the future? Given the past performance and the present condition of the program, a look towards the future is in order. Previous performance is presented in Figure 3.1 as total Federal dredging expenditures for both navigational and non-navigational related work between 1964 and 1973. Dredging expenditures for navigational work account for an average 94% of the total expended and no less than 91% during any single year considered. Both current and constant (1964 GNP Implicit Price Deflator) dollars have been used in describing these expenditures to remove the effects of inflation during the period. The annual volume of material removed is unavailable prior to FY 1968 but has been shown for the remainder of the period. It can be seen that in current dollars, expenditures have increased from $138M in 1964 by some 20% to $168M in 1973. Expenditures have grown at an average compounded rate of 5% per year since 1967. However, in constant 1964 $'s, actual purchasing power has remained relatively constant since 1967 with a mere 0.2%/year decline noted between 1968 and 1973. Concurrently the volume of material dredged is seen to have increased from 340M cubic yards (CY) in

*The data base for this discussion was developed from the Corps of Engineers thirty-eight district offices by Arthur D. Little, Inc. in a study entitled Report on the National Dredging Program. The data excerpted from this study is contained in Appendix A.

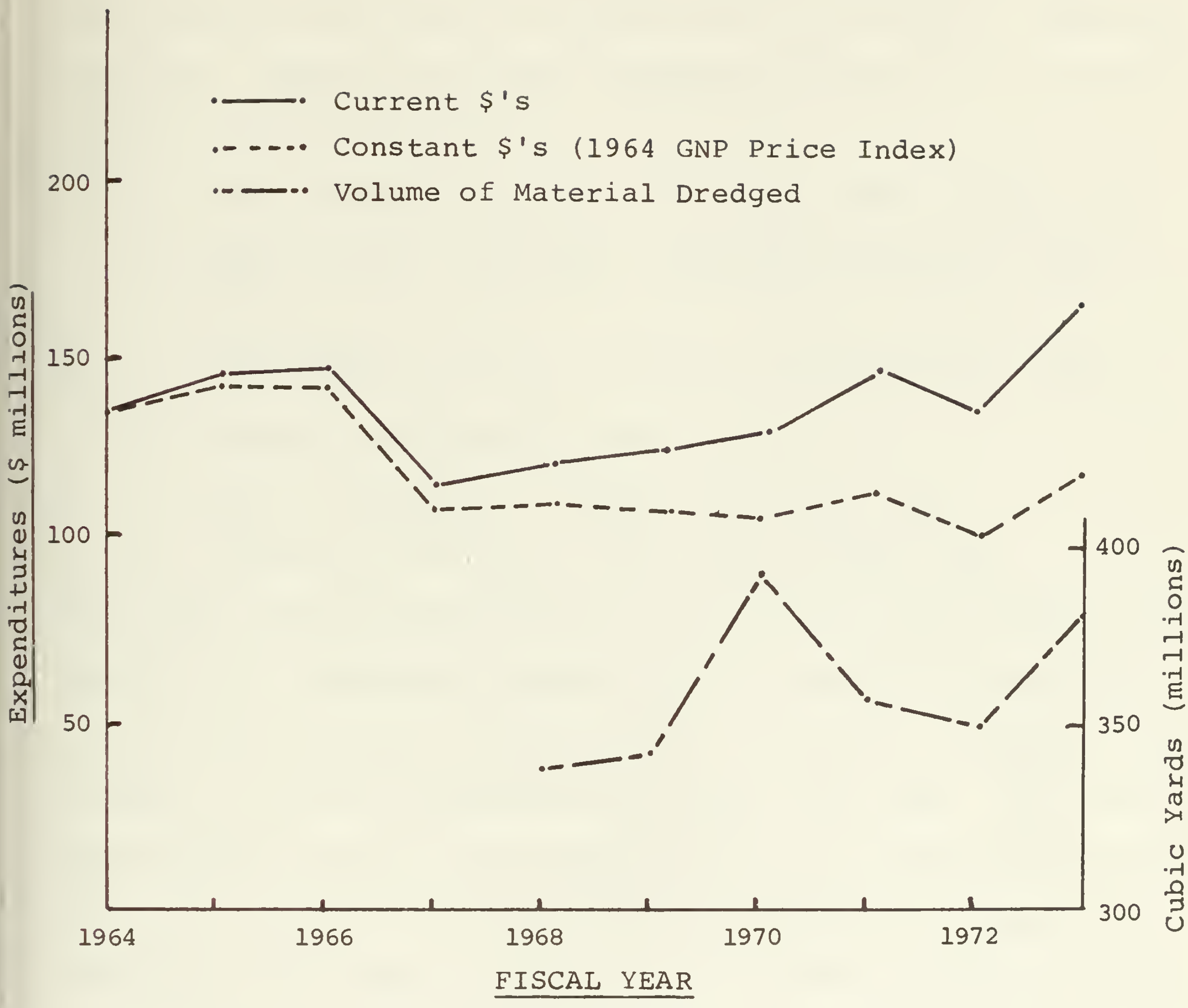


Figure 3.1. Total Federal Dredging Expenditures and Volumes. Source: A.D. Little, Inc. (25)

1968 to 380M CY in 1973. Therefore, despite the difficulties of the past 5 years, the Federal Dredging Program has experienced a decrease in the cost per cubic yards ($CY) of material removed. This might superficially suggest an increase in efficiency of the program contradicting the concerns expressed earlier. However, the cost of dredging material is a function of the following variables:

1) Material Composition - mud, rock, sand, gravel, etc.
2) Local water conditions - current, turbidity, depth, etc.
3) Geographic location - traffic, environmental concern, etc.
4) Weather conditions - wind, waves, etc.
5) Type of equipment - dredge type, age, etc.
6) Method of disposal - open water, diked, etc.

The more costly combinations of these factors are found in the cost of "new" dredging projects which in general exceed the costs of maintenance dredging by 50%. Figure 3.2 depicts the trends in new and maintenance work cost with time. The cost of maintenance dredging has remained constant at $0.27/CY over the past six years, while the cost of new dredging has been considerably less stable from a low of $0.35/CY in 1970 to a high of $0.50/CY in 1973. This instability in the price of new dredging work may be attributable to increased environmental standards and fiscal restraint policies. The cost of new dredging is sensitive to enviornmental restrictions requiring more costly methods of spoil disposal. The increase noted in the

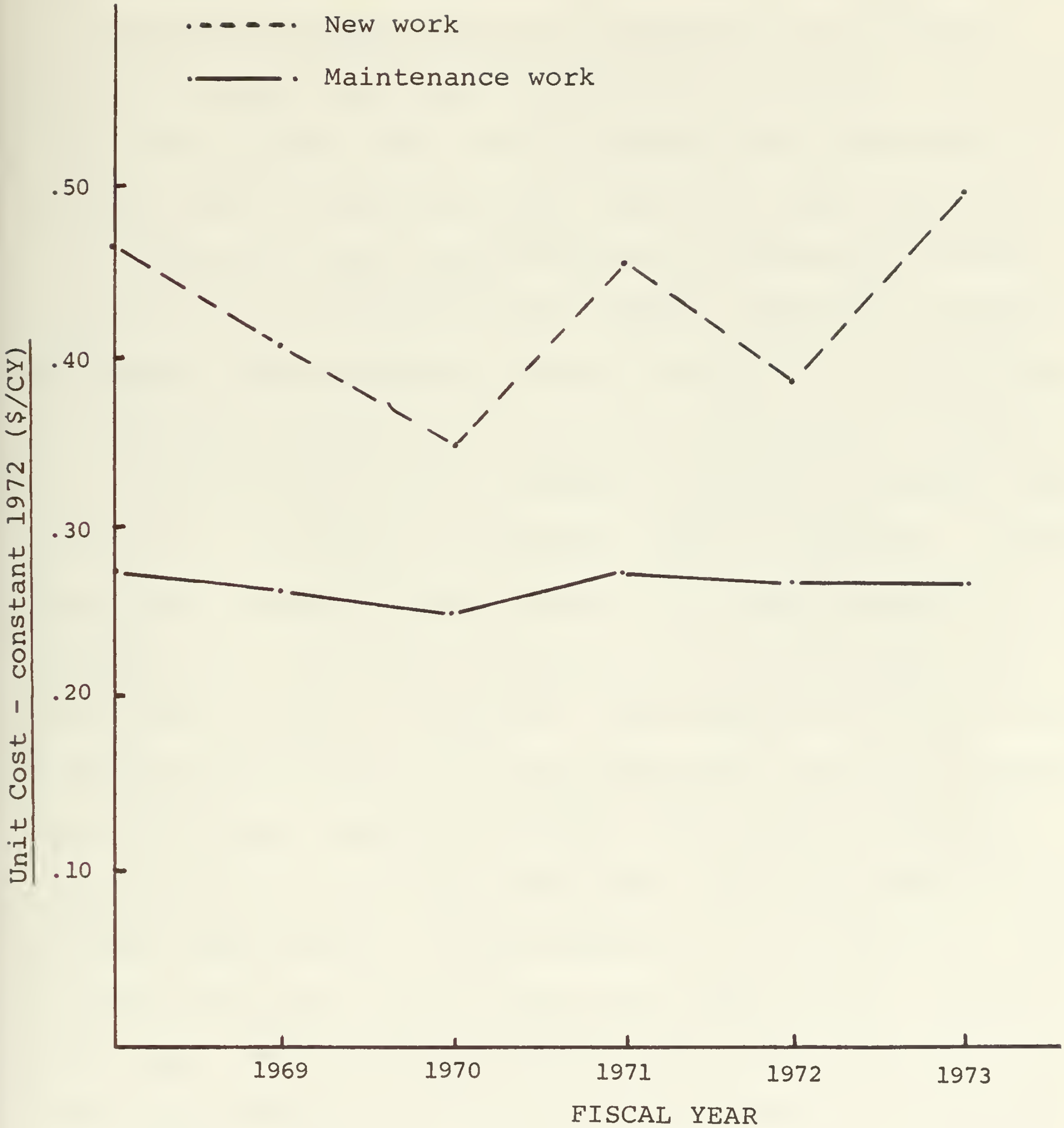


Figure 3.2. Unit Cost of Dredging for New and Maintenance Work (Appendix A)

cost of new work in 1970 coincides with the imposition of the E.P.A.'s "Jensen Memorandum" restricting the open-water disposal of "polluted" spoil. These criteria developed from Great Lakes data were imposed nationwide with the result that by 1972 31% of all maintenance dredged spoil was classified as "polluted". To prevent a severe curtailment of dredging activities, particularly on the Great Lakes, the Corps of Engineers was authorized to purchase land in the Great Lakes region for diked disposal sites. (22) Nationwide, open water disposal was curtailed and more expensive means of disposal were adopted. With the passage of the Federal Water Pollution Control Act of 1972, the Corps as the licensing authority was required to hold public hearings for on-going as well as new dredging projects and charged with the review of related Environmental Impact Statements. Finally, Public Civil Works programs (under which dredging funds are appropriated) are primary candidates for appropriation cut-backs during times of inflation. The combined effect of the growing environmental and fiscal restraints has been a reduction in new work dredging projects. The Interior Waterways Region has had no new work since 1965. The Great Lakes Region has been experiencing a steady decline in new work since 1969 and Gulf Coast new work programs were substantially cutback in 1973. (25) The new work cutbacks on the Gulf Coast were undoubtedly influenced by the sizeable increase in maintenance work along the Mississippi River made necessary by the flood water levels of 1973.

The shift of expenditures away from new work projects may be seen in Figure 3.3. Since 1969 new work volumes have been decreasing at an annual rate of 6.6%/year, while maintenance

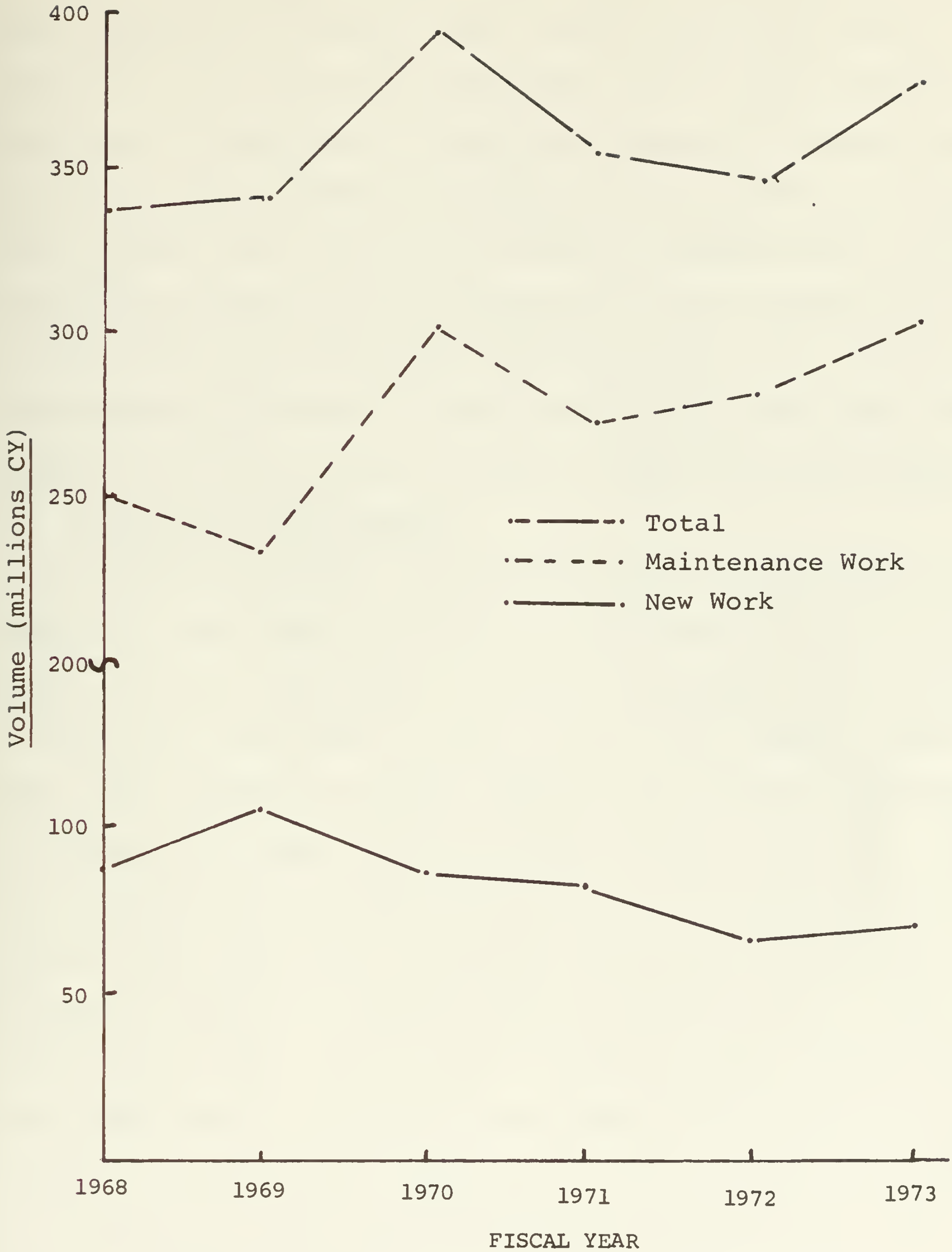


Figure 3.3. Federal Dredging Volumes - New and Maintenance Work (Appendix A)

work has been increasing at the same rate. With a larger share of the overall budget devoted each year to accomplishing the less expensive maintenance work, larger volumes have been achieved. It is for this reason that a relatively constant expenditure has purchased an increasing amount of dredged volume and is not due to greater efficiency in the program. It must be borne in mind that the level or growth in expenditures, such as depicted by Figure 3.1, has no bearing on the program's ability to meet either past or future dredging demand. The expenditure history merely reflects the appropriation decisions that have emerged from the political process in answer to local demand.

3.1 Projecting Future Demand

To judge the Federal Dredging Program's effectiveness in answering actual demand would require volume estimates of all requests whether completed, rejected or deferred, and a means to gauge the "worthiness" of each request for Federal completion. The resulting "worthy" demand might then be time-lagged to reflect the delays inherent in the process. The time lags for Civil Works Projects from request through to completion between 1958 and 1971 have been investigated and found to approach some 18 years of which an average 2 years 8 months is for actual construction. (28) Finally, this demand and the expenditures over time could be compared to determine effectiveness of the program. Lacking such a demand curve and the means to produce it, planning for the future needs and the capacity of the Federal Dredging Program is at best imprecise. The data collection necessary to measure total dredging demand is certainly within the capability of the present system. Time

lags in the system as previously mentioned are known and can be refined. The missing element, however, is an objective means to decide if a particular request should be approved for Federal accomplishment, i.e. the "worthiness" of the project. The U. S. Congress at present determines the "worth" of a project by an authorization or rejection vote. The Office of Management and Budget may further enhance the "worth" of a project by its recommendation for appropriation of the project funds. Lastly, a final vote in the Congress is required to appropriate funds. The waiting time alone for funds for an authorized project averages 2 years. (28) There are two separate decisions involved in determining a project's worth. The authorization decision on the part of Congress affirms or denies the "worth" of a project as promoting the national interest. The appropriation decision, on the other hand, directs itself to the practicality of funding a "worthy" project during a particular time frame. The approach of Congress to these decisions varies with time, mood and issues. In general, projects are submitted on an individual basis and lacking a National or even Regional port development policy stand on their local merits. Such a National or Regional policy would provide an objective means from which a project's worth could be formulated and later judged. It would lend direction to the development of a project, a port and a region. Most importantly it would provide the means by which future demand could be predicted and levels of appropriation planned. This type of policy whether for National port development or for a singular element such as dredging has been resisted in the past. Port Authorities and Congress have resisted such a step

in the interest of preserving individual port identity, rights and the promotion of competition. The Federal Dredging Program has maintained a neutral stance by essentially dredging all competitive ports to approximately the same depths. The end result has been a port system apparently plagued by over-capacity and the misallocation of federal funds from a national point of view. (20) More recently, a growing interest has been expressed by the Senate Public Works Committee on adopting a more objecttive approach to such Federal investments. (25) This committee makes appropriation recommendations for dredging projects.

There are adequate tools at hand to project over a reasonable period of some 8 years the adequacy of the Federal Dredging Program in its current form. Historic appropriation trends are available as shown in Figure 3.1. Arthur D. Little, Inc. has recently compiled and aggregated internal Corps of Engineers estimates of new work and maintenance dredging requirements through FY 1983. (25) These estimates were prepared by the thirty-eight Corps District offices and are based upon present projects, approved projects with work commencing during the period, and on project requests anticipated for commencement during the period. The projections were made with the assumptions that appropriations for new work were forthcoming, and that equipment availability and use would conform with best practices in the past. With these assumptions the resulting projections, although restrained by the systems' status quo, represent the most accurate predictions of future dredging demand available. They, therefore, are superior to the blind

extrapolation of past expenditures and should tend to account for needed new work that has been deferred. The projections were furnished in constant 1973 GNP dollars. To facilitate comparison with past expenditures, all costs have been adjusted to a common base using the GNP Implicit Price Deflator. A base year of 1972 was selected to conform with the present practices of The Survey of Current Business. This adjustment is recorded in Appendix A. The striking result when past expenditures are held up to projected future demand is demonstrated by Figure 3.4. The following observations are made:

1) The expenditure projected to meet the dredging requirements of 1979 represents a 120% increase over the 1973 appropriation.

2) Expenditures which have remained relatively constant since 1967 would be required to increase at a compounded rate exceeding 14%/year through 1979.

3) The volume required to be removed in 1979 (675M CY) represents a 75% increase over that amount removed in 1973.

3.2 The Implications of Future Dredging Needs

In view of the considerable increases in both expenditures and volume that the Federal Dredging Program faces, several critical questions arise. Firstly, can the massive increases in dredged spoil disposal be accomplished within the present environmental constraints? Is the Corps and contractor dredging fleet capable of processing or expanding to process the increased volume? Lastly, will the Federal government expand the appropriations for dredging programs at a rate sufficient to meet future requirements? The Corps of Engineers has taken steps to investigate new environmentally acceptable

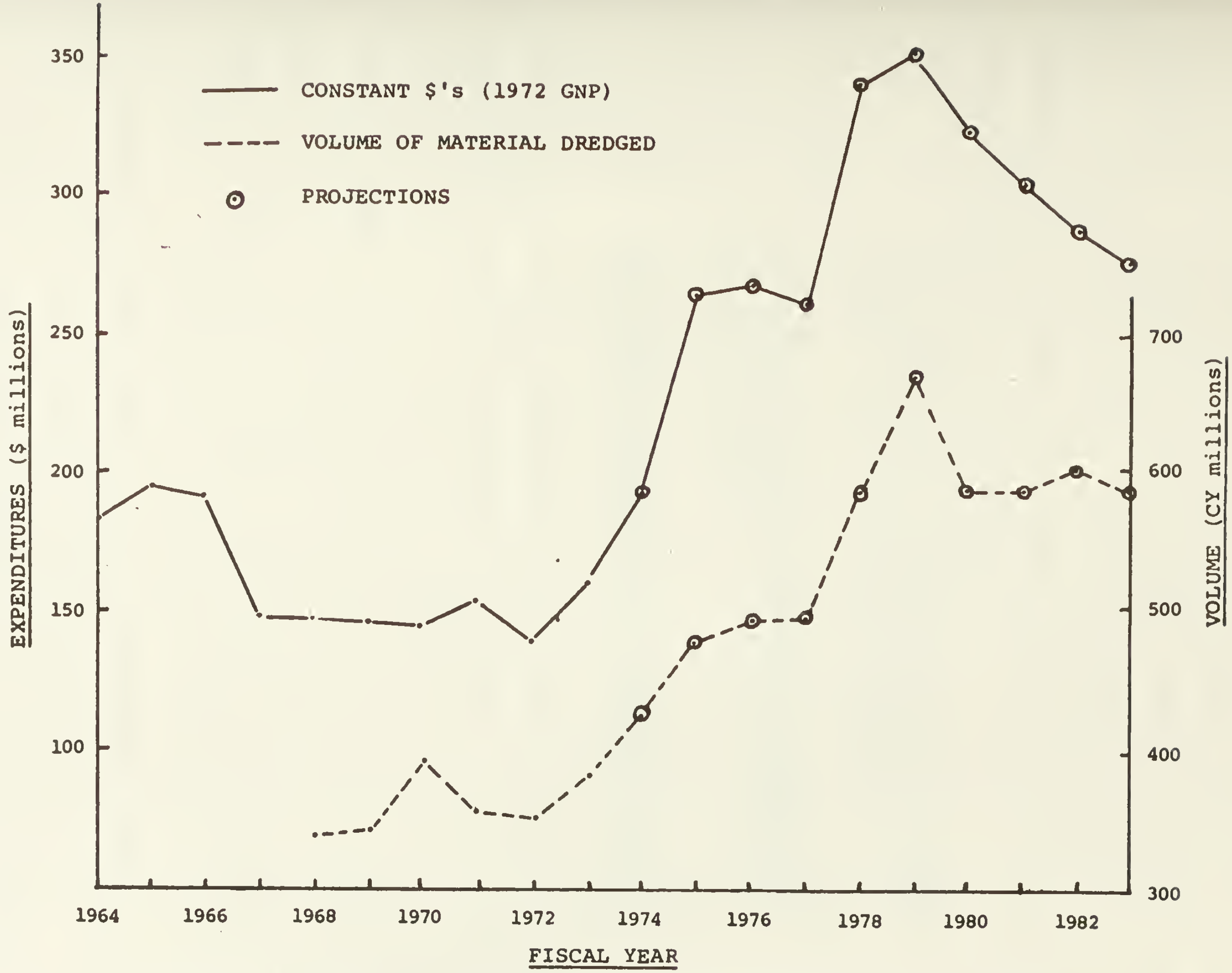


Figure 3.4. Federal Dredging Expenditures, Volumes and Projections (Appendix A)

methods of dredged spoil disposal. A five-year $30M study was commenced in 1973 by the Engineer Waterways Experiment Station of Vicksburg, Mississippi from which more economic means of spoil disposal are hoped to emerge. (23) The present capacity and future capability of both the Corps-owned and private contractor dredging fleets has been recently investigated by A. D. Little, Inc. (25) The general conclusions of the study concerning the present dredging plant's ability to meet the projected demand are as follows;

1) The Corps owned dredging fleet is highly utilized and the plant must be expanded to meet future dredging demands.

2) To meet the projected demand, the number of Hopper dredges must be increased by 61% and the number of Dustpan dredges by 50% by 1983.

3) The additional capital investment (1972) required to expand the dredging fleet will be $130M by 1979 and $250M by 1983.

The latter question concerning the future levels of Federal expenditures due to its political nature, is rent with speculation. On the one hand, the expenditure (1972) required in 1979 for dredging operations will be more than double that made in 1973. If, however, these expenditures are viewed in terms of the overall budget, the impact is considerably less shocking. Traditionally, navigational dredging funds have accounted for less than 0.2% of the entire Federal budget and less than 4% of all Federal Public Work funds. (20) In light of the trend in past expenditures, it appears improbable that a growth rate of 14%/year would be appropriated. In the absence of a Federal or Regional policy directing the growth of

such projects, it is highly likely that the haphazard approach of the past to such funding will continue. The "worth" of a project will be determined in part by the amount of influence that local interests can bring to bear on the authorization and appropriation decisions. Many proposed new work projects will continue to be deferred or rejected. Some new work demands denied Federal funding will be accomplished under the non-Federal budget and then transferred for Federal maintenance. Federal funds may be expended on local interest projects, apparently, to the detriment of projects more fitting to the national interest.

Looking forward to the task ahead, the Federal government must assume a planning stature in directing the level of funding for dredging projects. Appropriations must be made in light of a project's overall Regional or National impact. Such a policy must generate national or regional alternatives. Three options are apparent in dealing with the projected dredging demand:

1) Expand appropriations at a rate consistent with demand (i.e., 14%/year plus the rate of inflation).

2) Reduce the cost per cubic yard of dredged material by relaxing environmental standards and/or improving the technology of dredging operations.

3) Reduce the volume of demand through adoption of alternatives to dredging.

The first option is rejected as merely an extension of the status quo and lacks any improvement in the present decision process. With the continuing high level of environmental concern evidenced

in this country, a reduction in dredging costs through the relaxation of standards appears remote. A central thrust of the Corps Vicksburg study is the reduction of dredging costs through new techniques and equipment. The average unit costs (1972) of dredging over the projected period is $0.52/CY. If dredging technology were to be improved to produce a 10%/year growtn rate on expenditures, a reduction in cost to $0.37%/CY would be required. Such a 30% reduction in costs is judged unlikely as forthcoming from the Corps' study. The ability of the second option to limit the growth of expenditures to a reasonable rate is considered extremely remote. The development of alternatives to dredging has long been an integral part of the review process to dredging requests. However, alternatives as generated by the District Engineer are necessarily limited to scope of the local project. Alternatives have not been generated around regional or national interests. Herein lies a major fault of the present system; Congress is required to make national decisions on proposals containing at best limited national information. The result has been long time delays and a haphazard decision process. A process to identify and evaluate national and/or regional alternatives to dredging requests is needed and will be pursued.

3.3 A Regional View - The Gulf Coast

It is revealing to examine the regional demand components of Figure 3.4. If the total projected dredging demand is broken down into the five major coastal regions, the resulting regional contributions to volume and cost are as shown in

Figures 3.5 and 3.6. Of note, is the Gulf Coast component which includes all waterways tributory to the Gulf of Mexico (the Mississippi River to Baton Rouge) and their contiguous areas. This region alone accounts for some 60% of the volume and 45% of the cost of the projected dredging demand. It is seen that while the volumes of the remaining four regions remain approximately constant over the period, the Gulf Coast demand grows by 12%/year through 1979 or by 5.8%/year over the period. A similar pattern is exhibited in the cost of dredging (Fig. 3.6). The relatively cheaper dredging cost ($/CY) on the Gulf Coast, however, cushions this region's overall impact while the more expensive cost on the East Coast emphasizes the effect of that region. If an attempt is to be made to reduce the projected volume of dredging, the Gulf Coast region is clearly the primary candidate for beginning such an investigation. This is not to say that this region's demand is less critical than the remainder of the nation. Rather, if reductions are possible nationwide, any made in the Gulf Coast region will have a significantly larger overall effect. By way of an example, if a 10% reduction is achieved over the ten-year period in the Gulf Coast demand, a nationwide reduction of 6% will result while the national reduction would only be 1.5% if achieved on the East Coast.

The Gulf Coast region is composed of the Jacksonville (west Florida coast), Mobile, New Orleans and the Galveston Corps of Engineer Districts. Excluding the Jacksonville district, the Region enjoys the lowest cost ($/CY) of dredging in the nation.

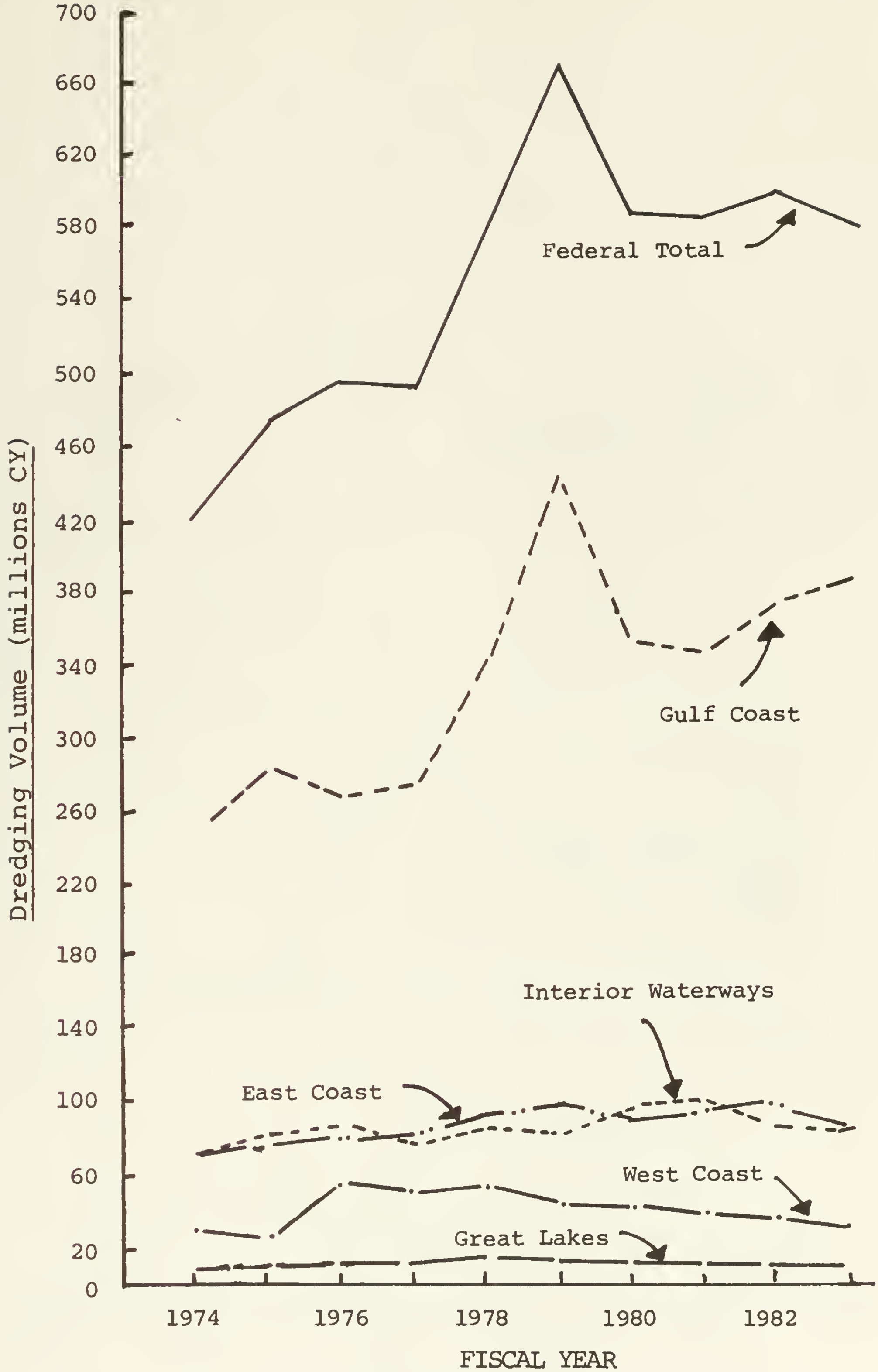


Figure 3.5. Regional Contribution to Total Dredging Volume. Source: The National Dredging Study (25)

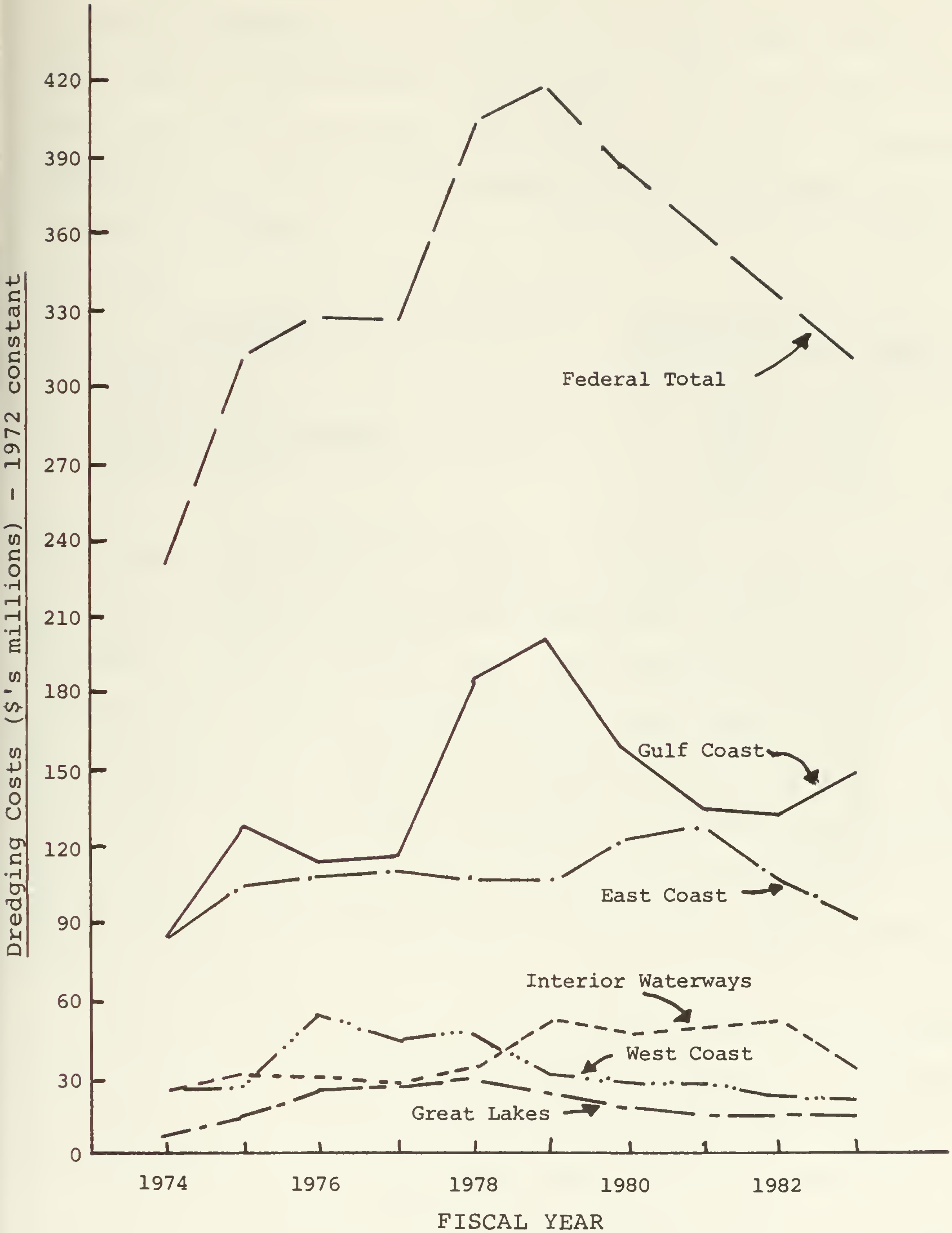


Figure 3.6. Regional Contributions to Total Dredging Expenditures. Source: The National Dredging Study (25)

Dredged spoils mainly composed of unconsolidated silt and sand are readily removed. As a result of the region's long-standing economic dependence on all phases of the petroleum industry, tne region's environmental restrictions tend to be less severe than the nation as a whole. The reduced unit cost of maintenance dredging over the projected period for the Gulf Coast region is evident as follows:

Region	Dollars/Cubic Yard
Gulf Coast	0.27 - 0.60
West Coast	1.50 - 7.00
Interior Waterways	0.25 - 0.80
Great Lakes	1.05 - 6.70
East Coast	0.75 - 1.70

The Jacksonville district, however, is unique to the region due to more stringent environmental restrictions and spoils that are composed of rock and heavy sand. The resulting higher dredging costs for maintenance in this district range from $0.80 to $1.60 per cubic yard over the period. The projected demand for the Gulf Coast region is mainly influenced by the new work projects described in Table 3.1. These new work projects account for approximately 45% of the volume and 60% of the cost of the region's demand.

The Gulf Coast Region is therefore selected for an in-depth investigation to identify alternatives to dredging. In particular the new work projects scheduled for commencement between 1974 and 1983 will be scrutinized from a regional viewpoint. Any regional dredging alternatives will subsequently be researched

TABLE 3.1

GULF COAST REGION MAJOR NEW YORK PROJECTS

(1975-1983)

DISTRICT	PROJECT DESCRIPTION	COMMENCE (FISCAL YEAR)	CHANNEL PROJECT DEPTH OLD	NEW	VOLUME REMOVED (MCY)
JACKSONVILLE	DEEPEN APPROACH TO TAMPA BAY	1975	34'	43'	18M CY/YR. THRU 1983
MOBILE	COMPLETE TENNESSEE TOMBIGBEE WATERSAY	1975	9'	9'-12'	20M CY/YR. THRU 1981
	DEEPEN APPROACH TO PANAMA CITY	1975	32'	40'	
	DEEPEN APPROACH TO GULFPORT	1976	30'	34'	
NEW ORLEANS	DEEPEN MISSISSIPPI RIVER & MISS. RIV. GULF OUTLET (MRGO)	1979	36'	55'	35M CY/YR. THRU 1983
GALVESTON	DEEPEN GALVESTON HBR. (INSHORE DEEP-WATER PORT)	1978	40'	60'	20M CY/YR. THRU 1983
	DEEPEN CORPUS CHRISTI HARBOR (INSHORE DEEPWATER PORT)	1977	45'	76'	50M CY/YR. THRU 1980

Source: A. D. Little, Inc. The National Dredging Study, 1975

for their overall impact on the projected national dredging budget.

CHAPTER 4

WATERBORNE TRANSPORT ON THE GULF COAST

4.0 Identifying Deep-Draft Cargo Requirements

The first task in developing alternatives to the dredging of the Gulf Coast region waterways is to identify the particular needs behind the demand for dredging. Alternatives subsequently formulated will be judged upon their ability to meet those needs found to be in the regional interest. Ideally, one might review past dredging requests or directly contact the sources of such requests, i.e., port authorities, transportation companies, shippers and local interest groups to discern these water transport needs. A great deal of accurate information might be gathered in this manner but only at large expense in time and funds. Consequently, water transport needs will be deduced from a more aggregated source of information. Waterborne Commerce of the United States is a major source of information concerning the usage of Federally maintained waterways. Publication is annual by the Corps of Engineers and reports commodity and marine vehicle movement utilzing the Commodity Classification for Shipping Statistics system. Cargo transport is recorded by commodity type, transit route, tonnage, vessel type, vessel movements and vessel draft for each waterway. The first section of this chapter will be devoted to the identification of deep draft cargoes and their transport vessels utilizing the waterways of the Gulf Coast region. It is assumed that the thrust of a navigational dredging request is the selection of a project depth to accommodate the economic transport of certain cargoes to a local area. A request for a deeper project depth would

more commonly be related to the desired transit of a deeper draft vessel through the waterway. Those cargo/carrier combinations which transit a waterway at or near to its project depth, constitute the most stringent need that a waterway must meet. A causal relationship between project depth and deep-draft cargoes might therefore be expected to exist. The second section of this chapter will attempt to verify the existence of such relationships for the Gulf Coast waterways. Once the dependence of project depth and the transport of a particular cargo is identified, alternatives to the present means of transport may be investigated. If a regional alternative to the shipment of those cargoes is found, then a savings to the dredging budget may result through a reduction in project depth.

Although changes in project depth are approved intermittently by Act of Congress, a trend is evident over the past decade. Table 4.1 provides a listing of the maximum vessel drafts and the project depths for those waterways on the Gulf Coast dredged in excess of 15 feet and trading in more than one million short tons of cargo in 1974. A trend of ever deeper vessels and deepening waterways is evident. The Galveston Corps of Engineers district is the only area for the waterways considered where project depths have significantly increased in the past decade. However, increasing project depths are anticipated in all districts in the forthcoming decade.

The waterways of the Gulf Coast form an impressive and complex transport system. In excess of twenty major ocean-going waterways link coastal port areas to the Gulf of Mexico. The Gulf Intracoastal Waterway system serves all of the major

TABLE 4.1

VESSEL DRAFTS AND PROJECT DEPTH

FOR SELECTED GULF COAST WATERWAYS

PORT AREA	MAXIMUM VESSEL DRAFT RECORDED (FEET)			PROJECT DEPTH (PD) HARBOR AREA (FEET)			FUTURE REQUESTS* THRU 1983
	1964	1969	1974	1964	1969	1974	
TAMPA, FLA.	36	35	36	34	34	34	43
PANAMA CITY, FLA.	31	32	32	32	32	32	32
PENSACOLA, FLA	32	32	32	33	33	33	33
MOBILE, ALA.	37	40	40	40	40	40	40
PASCHAGOULA, MISS.	37	38	40	38	38	38	38
NEW ORLEANS, LA.	40	40	40	40	40	40	50
BATON ROUGE, LA.	42	40	45	40	40	40	50
LAKE CHARLES, LA.	36	38	34	40	40	40	40
ORANGE, TX.	31	31	32	30	30	30	30
BEAUMONT, TX.	40	37	40	40	40	40	40
PORT ARTHUR, TX.	40	38	40	36	36	40	40
HOUSTON, TX.	37	40	39	36	40	40	40
TEXAS CITY, TX.	36	37	38	40	40	40	40
GALVESTON, TX.	37	40	40	36	36	40	60
FREEPORT, TX.	35	36	36	36	36	45	45
CORPUS CHRISTI, TX.	39	40	40	40	40	45	45
HARBOR ISLAND, TX.	39	40	40	40	40	45	72
BROWNSVILLE, TX.	35	35	35	38	36	36	36
AVERAGES	36.7	37.2	37.7	37.2	37.3	38.8	43.0

*Based on Table 3.1

Source: Waterborne Commerce 1964, 1969, 1974

port areas (via the Mississippi River to Baton Rouge, La.) extending from Apalachee Bay, Florida to the Mexican border. In 1974 this Waterway carried 103M short tons (s.t.) of 140 different cargoes in vessels drawing less than 15 ft. of water. For this same year the Mississippi River system, the largest tonnage carrier in the U. S., accounted for the transport of approximately 145 types of cargo with a total weight of 302M s.t. The scope of transport activity remains complex even when limited to a single project. The Houston Ship Channel is comprised of approximately 72 miles of Federal maintained waterways. However, 89M s.t. of 150 different cargoes were carried by this waterway on vessels with drafts up to 90 ft. The following guidelines have been adopted to reduce the complexity of the system to more manageable dimensions:

1) Only waterways with project depths exceeding 15 ft. will be considered. This will eliminate from consideration the entire Gulf Intracoastal Waterway subsystem and like waterways. These waterways transport varied types of cargo at approximately the same draft.

2) Only the needs of deep-draft cargoes will be satisfied. ("Deep draft" cargoes will be subsequently identified.) This follows the assumption that if cargoes with the most demanding needs are met then those cargoes carried at shallower drafts will be satisfied.

3) The requirements for "Domestic Internal" and "Local" bound cargoes will not be addressed. These transit routes as defined by Waterborne Commerce are characterized by transport in shallow draft carriers and/or over inland routes of less than 15 feet of water.

4.1 Principal Ocean-Going Cargoes

An attempt will be made to identify for each of the major

Gulf Coast waterways those cargoes and carriers which most frequently transit at or near the given project depths. Economies to scale are present in the transport of most dry and liquid bulk cargoes. The transport savings resulting from such economics are in general a function of transport distance and vessel size. A commonly used gross measure of a vessel's cargo carrying capacity is Dead Weight Tonnage (DWT). This value is the difference between the full load and light load displacement of a vessel. In addition to cargo, DWT also includes the weight of personnel, stores, non-cargo liquids, consumables, etc. However, for bulk carrier vessels, the actual cargo carrying capacity may come very close to the value of DWT as follows:

DWT	Cargo Carrying Capacity
Below 40K:	Approximately equals 90% DWT
40K - 70K:	Approximately equals 92% DWT
Above 70K:	Approximately equals 95% DWT

Dead Weight Tonnage has been directly related to transport cost and distance for crude oil bulk carriers by Cooke and others. (29) Considering the increases in the size of dry bulk carriers and more recently in container carriers, the existence of similar relationships for other cargoes shipped over long distances is assumed. Therefore, one might first look to the dry and liquid bulk cargoes transiting the Gulf Coast waterways to identify those cargoes carried in the deepest vessels. Shipping Statistics and Economics, published by H. P. Drewry (Shipping Consultants) Ltd., London was consulted for the period July 1974

through June 1975. These statistics, published monthly, record the worldwide movement of liquid and dry bulk commodities. Listed therein is the type of cargo, size of carrier and the origin and destination of the shipment for certain vessel charters. The U. S. Dept. of Commerce (30) also lists those major commoditities traded in the Gulf Coast region on the major foreign trade routes established by the Maritime Administration. The cargoes found to be most commonly traded from the Gulf Coast in ocean-going vessels are listed in Table 4.2. With this listing of probable deep-draft cargoes, Waterborne Commerce was entered to construct the transport patterns for each of the Gulf Coast waterways with depths exceeding 15 feet. Of the waterways meeting this depth requirement listed in Appendix B, thirty were chosen for analysis. Weedon Island, Fla., a non-Federal project, was eliminated. Chicksaw Creek, Ala., Atchafalya River, La., Orange Harbor, TX., and Sabine Pass Harbor, Tx. were eliminated as greater than 95% of the cargo for these projects is carried on the inland waterways. Waterborne Commerce does not provide individual cargo statistics for Galveston Harbor, Tx., Port Isabel, Tx., and the Passes of the Mississippi River and these waterways were eliminated. The cargo movement on these latter three waterways is, however, included in their connecting waterways. Waterborne Commerce for the years 1971 through 1974 was reviewed for any major changes in either cargoes shipped or types and drafts of carrier vessels. No major shifts in cargo shipment patterns were noted

TABLE 4.2

PRINCIPAL OCEAN-GOING CARGOES AND CARRIERS

OF THE GULF COAST REGION

CARGO	COMPONENTS	CARRIER SIZE (1000's DWT)	ORIGIN	DESTINATION
Grain	Heavy Grain/ Sorgham/ Wheat/ Soya-beans	Largest=70	Gulf Coast	Foreign
Coal		Largest=45	Mobile	Foreign
Petroleum Coke		Largest=50	Port Arthur	Japan
Bauxite		Largest=36	Foreign	Baton Rouge
Phosphate Rock		Largest=58 Average=25	Tampa	Foreign
Sugar		Less,or=20	Foreign	Gulf Coast
Chemical Fertilizers		Less,or=15	Houston	India
Iron, Steel Scrap		Largest=24	Panama City	Foreign
Citrus Pellets		Largest=22	Tampa	Foreign
Rice		Largest=25	Gulf Coast	Foreign
Chrome Ore		Largest=30	Foreign	Gulf Coast
Crude Oil		45-62	Persian Gulf + Africa	Gulf Coast
		20-45	Caribbean	Gulf Coast
		15-35	Gulf Coast	Coastwise
Petroleum Products	Gasoline/ Kerosene/Jet Fuel/Distillate	15-35	Gulf Coast	Coastwise
	Residual	28-35	Foreign	Gulf Coast

Source: Shipping Statistics and Economics
H. P. Drewry 7/74 - 6/75

and the most recent statistics (1974) were judged sufficient for the analysis. The shipments in short tons for the selected cargoes for each of the waterways are indicated in Table 4.3. The tonnages recorded are for ocean-going routes only and include all "Foreign" and "Domestic-Coastwise" shipments. In selecting the final dozen cargo groupings, an effort was made to minimize the total number of cargoes considered while maximizing the percent of total ocean-going tonnage.

The effort to identify those cargoes principally trading on ocean-going routes has been modestly successful. With the twelve cargo groupings arrived at, an average 81% of all ocean-going tonnage has been accounted for. If only the Grain, Ore, Crude Oil and Petroleum Product groupings are considered, greater than 70% of the ocean-going tonnage continues to be recorded for the region. As might be expected, this suggests that only a select few cargoes contribute significantly to the total ocean-going trade. It reasonably follows that preliminary efforts in the generation of alternatives to dredging should be concentrated around the transport needs of these cargoes. The identification of transport requirements for a given waterway is only half complete with the description of the principal cargoes carried. Carrier vessel type and size must be associated with each of these cargoes and can be expected to vary between waterways. Once cargo/carrier combinations are found that require the full project depth then they will be considered "deep-draft" cargoes.

Section 2 of the annual Waterborne Commerce statistics reports for each waterway the transit drafts of vessels and

TABLE 4.3

PRINCIPAL OCEAN-GOING COMMERCE ON THE GULF COAST WATERWAYS

(millions short tons)

WATERWAY	ENTRANCE CONTROLLING DEPTH (ft.)	% of TOTAL OCEAN-GOING TONNAGE	GRAIN 0102-0107 & 2049	BANANAS 0132	ORES 1011 & 1051	COAL 1121	CRUDE OIL 1311	PHOSPHATE ROCK 1471	SULPHUR LIQUID 1493	SUGAR 2061	PULP 2611 & 2631	PETROLEUM PRODUCTS & CHEMICALS 2911, 2911 & 2917	PETROLEUM COKE 2913 & 3313	SCRAP 4011
JACKSONVILLE DISTRICT														
St. Petersburg	20	98	0	0	0	0	0	0	0	0	0	0.053	0	0
Tampa	35	86	NIL	NIL	0	3.5	0	17.7	2.1	NIL	NIL	11.17	NIL	NIL
MOBILE DISTRICT														
Port St. Joe	35	87	NIL	0	0	0	0	0	0	0	NIL	0.308	0	0
Panama City	32	85	0	0	0	0	0	0	0	0	0.223	0.302	0	0.05
Pensacola	33	68	NIL	0	0	0	0.176	0	0	0	NIL	0.178	0	0
Mobile	36	84	1.1	NIL	8.4	1.9	3.4	0	0	0	NIL	NIL	NIL	NIL
Three Mile Creek	30	97	NIL	0	3.2	1.8	0	0	0	0	0	NIL	NIL	0
Pascagoula	38	93	1.5	0	0	0	1.4	0.6	0	0	0	3.0	0	0
Bayou Casotte	38	94	NIL	0	0	0	1.4	0.5	0	0	0	3.0	0	0
Gulfport	28	59	0.43	0.39	0	0	0	0	0	0	0	NIL	NIL	0
NEW ORLEANS DISTRICT														
Inner Harbor Nav. Canal	28	27	0.672	0	0	NIL	0	NIL	0	NIL	NIL	NIL	NIL	NIL
M.R.G.O.	35	59	1.1	0	NIL	NIL	0	0.201	0	0.29	NIL	NIL	0.509	0.243
Calcasieu River & Pass	36	80	NIL	0	0	0	23	0	0	0	NIL	2.4	NIL	NIL
Baton Rouge (B.R.)	40	73	.53	NIL	46	NIL	44	NIL	0	NIL	NIL	7.5	NIL	NIL
New Orleans (N.O.)	40	67	23.8	NIL	NIL	NIL	8.6	NIL	NIL	NIL	NIL	8.2	NIL	NIL
Miss. River B.R. to N.O.	40	82	22.5	NIL	7.0	NIL	14.8	NIL	0	NIL	NIL	12.4	NIL	NIL
Miss. River N.O. to Pass.	40	73	36.8	NIL	7.1	NIL	22.6	NIL	NIL	NIL	NIL	15.8	NIL	NIL
GALVESTON DISTRICT														
Sabine-Neches Waterway	38	87	3.5	0	NIL	NIL	19.5	0	NIL	0	NIL	13.0	NIL	NIL
Beaumont	33	88	2.7	0	NIL	0	9.5	0	NIL	0	NIL	8.3	NIL	NIL
Port Arthur	41	96	NIL	0	0	NIL	10.0	0	0	0	NIL	9.8	1.9	0
Houston Ship Channel	35	78	109	0	NIL	NIL	14.8	NIL	0	NIL	NIL	20.8	NIL	NIL

TABLE 4.3 (cont'd)

TEXAS CITY CHANNEL	38	90	0	0	0	0	2.7	0	0	0	0	54	NIL	0
GALVESTON CHANNEL	40	58	2.3	NIL	0	NIL	NIL	0	0.96	0.41	NIL	NIL	NIL	0
FREEPORT HARBOR	34	88	NIL	0	0	0	2.1	0	0	0	0	2.5	0	0
MATAGORDA SHIP CHANNEL	35	95	0	0	38	NIL	0	0	0	0	0	0.216	0	0
CORPUS CHRISTI SHIP CH.	40	97	36	0	4.4	NIL	10.5	0	0	0	0	98	NIL	0
HARBOR ISLAND	375	98	NIL	0	0	0	30	0	0	0	0	NIL	0	0
CORPUS CHRISTI	38	96	36	0	44	NIL	7.6	0	0	0	0	96	NIL	0
BRAZOS ISLAND	37	76	0.232	0	NIL	0	0.276	0	0	0	NIL	0.31	0	NIL
BROWNSVILLE	37	78	0.227	0	NIL	0	0.278	0	0	0	NIL	0.309	0	NIL

EXCERPTS FROM THE COMMODITY CLASSIFICATION FOR SHIPPING STATISTICS

0102	BARLEY & RYE	2061	SUGAR
0103	CORN	2611	PULP
0104	OATS	2631	PAPER & PAPERBOARD
0105	RICE	2819	BASIC CHEMICALS
0106	SORGHUM GRAINS	2911	GASOLINE
0107	WHEAT	2912	JET FUEL
0132	BANANAS & PLANTAINS	2913	KEROSENE
1011	IRON ORE & CONCENTRATES	2914	DISTILLATE FUEL OIL
1051	BAUXITE & ALUMINUM ORES	2915	RESIDUAL FUEL OIL
1121	COAL & LIGNITE	2916	LUBRICATING OIL
1311	CRUDE PETROLEUM	2917	NAPTHA, MINERAL SPIRITS...
1471	PHOSPHATE ROCK	2920	COKE
1493	SULPHUR, LIQUID	3313	COKE (coal & petro.)
2049	GRAIN MILL PRODUCTS	4011	IRON & STEEL SCRAP

NIL ≡ less than 5% total waterway tonnage

Source: <u>WATERBORNE COMMERCE</u>, 1974

the number of trips made over a waterway. This information is reported for the Passenger and Dry Cargo (P&DC), Tanker and Tugboat vessel types. The direction of transit and the presence of a propulsion system is also indicated. The 1974 Section 1 and Section 2 statistics for two waterways have been reproduced in Table 4.4. The procedure used in first identifying "deep-draft" cargoes and second verifying and defining the causal relationship between those cargoes and project depth is presented below:

<u>St. Petersburg Harbor, Fla.</u> - Residual fuel oil was identified in Table 4.3 as the major ocean-going cargo for this waterway. Section 1 of Table 4.4.a indicates that this cargo is received in coastwise commerce. Residual fuel oil may be received in either tankers and/or towboat powered barges. An examination of Section 1 also reveals that Residual fuel oil is the only cargo received in coastwise commerce that would be carried in tankers. Therefore, the "inbound" tankers at the 10 ft. and 11 ft. drafts reported in Section 2 are assumed to carry this cargo. A principal cargo/carrier combination has been identified. However, the transit of Residual fuel oil has not occurred at or near the waterways' project depth of 19 ft. Instead, the cargoes carried by the "outbound" towboats at 14 ft. and 15 ft. and those carried by the Passenger and Dry Cargo (P&DC) vessels from 11 ft. through 15 ft. are the "deep-draft cargoes. Since the cargoes of the Towboats and P&DC vessels cannot be deduced from Section 1, a causal relationship for this waterway cannot be verified without additional local shipment information.

<u>Port St. Joe Harbor, Fla.</u> - 87% of this port's ocean-going commerce is attributable to the transit of Residual fuel oil. Section 1 of Table 4.4b indicates that this cargo is received in both Foreign and Domestic Coastwise commerce. Ignoring the negligible transfers of cargo No. 2891, Residual is also the only product that would be carried in tankers on the waterway. Therefore, the principal cargo/carrier combination for this waterway has been identified. Secondly, waterway traffic is exclusively made up of this combination at drafts above 29 ft. and therefore Residual fuel oil is the sole "deep-water" cargo of the waterway. A causal relationship is

TABLE 4.4a

WATERBORNE COMMERCE OF ST. PETERSBURG HARBOR, FLA.

CTION 1.

ST, PETERSBURG HARBOR, FLA.

TIDN INCLUDEO: ENTRANCE CHANNEL, LOWER TAMPA BAY TO AND INCLUDING THE BASINS "PORT OF ST. PETERSBURG" AND "BAYBDRO HARBDR", 7.2 ES; CHANNEL SOUTHWESTERLY FROM UPPER TAMPA BAY (PORTION OF CHANNEL CONNECTING WITH THE PORT TAMPA CHANNEL DF TAMPA HARBOR, FLA.) TD CTION WITH ENTRANCE CHANNEL, 1.7 MILES; SALT CREEK TO FOURTH STREET BRIOGE, 0.5 MILE. CONTROLLING OEPTH: 19 FEET IN ENTRANCE NNEL, 16 FEET THROUGHOUT THE PORT OF ST, PETERSBURG BASIN, AND ABOUT 12 FEET TO AND IN BAYBORD HARBOR; 12 FEET IN CHANNEL IN THE TH OF SALT CREEK AND THENCE 9 FEET IN SALT CREEK TO NEAR SECOND STREET SOUTH, 0.3 MILE, BY AVOIDING SHOAL AREAS; AND ABOUT 20 FEET CHANNEL FROM UPPER TAMPA BAY. PROJECT DEPTH: 20 FEET IN ENTRANCE CHANNEL NORTHERLY FROM LOWER TAMPA BAY, 5.7 MILES, 19 FEET THENCE TERLY TO 24-FOOT CHANNEL, 0.2 MILE; 24 FEET IN CHANNEL FROM UPPER TAMPA BAY, SOUTHWESTERLY AND THEN WESTERLY THROUGH AND INCLUDING T OF ST. PETERSBURG TO BAYBORO HARBOR, 1.43 MILES; 12 FEET IN BAYBORO HARBOR BASIN, 1,400 FEET; AND 12 FEET IN CHANNEL IN THE MOUTH SALT CREEK, 300 FEET.

COMPARATIVE STATEMENT OF TRAFFIC

YEAR	TONS	PASSENGERS	YEAR	TONS	PASSENGERS
5	347,449	52,200	1970	467,682	20,064
6	282,703	4,800	1971	345,977	14,364
7	260,053	4,000	1972	506,501	10,400
8	274,855	6,000	1973	680,584	11,365
9	346,273	7,200	1974	306,854	14,680

OTE: PASSENGER TOTALS ABOVE EXCLUDES FERRY PASSENGERS.

FREIGHT TRAFFIC, 1974

(SHORT TONS)

COMMODITY	TOTAL	FOREIGN	DOMESTIC		
			COASTWISE	INTERNAL	
		IMPORTS	RECEIPTS	RECEIPTS	SHIPMENTS
TOTAL	306,854	1,162	53,367	252,305	20
1 FRESH FISH, EXCEPT SHELLFISH	947	933	----------	14	----------
1 MARINE SHELLS, UNMANUFACTUREO	119,400	----------	----------	119,400	----------
1 MEAT, FRESH, CHILLEO, FROZEN	3	3	----------	----------	----------
1 FISH ANO SHELLFISH, PREPAREO	50	50	----------	----------	----------
2 PREPARED ANIMAL FEEDS	156	156	----------	----------	----------
5 ICE	20	----------	----------	----------	20
1 VENEER; PLYWOOD, WORKED WOOD	20	20	----------	----------	----------
4 DISTILLATE FUEL OIL	132,891	----------	----------	132,891	----------
5 RESIDUAL FUEL OIL	53,367	----------	53,367	----------	----------

TOTAL TON-MILES, 2,393,247.

CTION 2.

TRIPS AND DRAFTS OF VESSELS

RBOR OR WATERWAY	DIRECTION						DIRECTION					
DRAFT (FEET)	SELF PROPELLED VESSELS			NON SELF PROPELLED VESSELS		TOTAL	SELF PROPELLED VESSELS			NON SELF PROPELLED VESSELS		TOTAL
	PASSENGER AND DRY CARGO	TANKER	TOWBOAT OR TUGBOAT	DRY CARGO	TANKER		PASSENGER AND DRY CARGO	TANKER	TOWBOAT OR TUGBOAT	DRY CARGO	TANKER	
				INBOUND						OUTBOUND		
PETERSBURG HARBOR, FLA.												
15									32			32
14	2					2	2		1			3
12	10					10	9					9
11	7	1				8	6					6
10	2	1		75	82	160	2	2				4
9	3		68			71	3	1	67			71
8	3		71	130		204			71			71
7	721		158	104		983	720		137			857
6 AND LESS	682		126			808	688		117	309	82	1,196
TOTAL	1,430	2	423	309	82	2,246	1,430	3	425	309	82	2,249

Source: Waterborne Commerce - 1974

TABLE 4.4b

WATERBORNE COMMERCE OF PORT ST. JOE HARBOR, FLA.

ECTION 1.

PORT ST. JOE HARBOR, FLA.

:TION INCLUDED: ENTRANCE AND INNER CHANNELS TO WHARVES. CONTROLLING DEPTH: ENTRANCE CHANNEL, 37 FEET; NORTH BAY (INNER) CHANNEL, TO 35 FEET; SOUTH BAY (INNER) CHANNEL, 27 FEET. PROJECT DEPTH: ENTRANCE CHANNEL, 37 FEET; NORTH BAY (INNER) CHANNEL, 35 FEET; TH BAY (INNER) CHANNEL, 27 FEET.

COMPARATIVE STATEMENT OF TRAFFIC

YEAR	TONS	YEAR	TONS
65	254,805	1970	931,762
66	301,045	1971	689,180
67	272,364	1972	668,601
68	301,713	1973	669,131
69	465,602	1974*	548,797

* PASSENGERS--11.

FREIGHT TRAFFIC, 1974

(SHORT TONS)

COMMODITY	TOTAL	FOREIGN		DOMESTIC		
				COASTWISE	INTERNAL	
		IMPORTS	EXPORTS	RECEIPTS	RECEIPTS	SHIPMENTS
TOTAL	548,797	43,371	45,940	264,450	30,245	164,791
41 FRESH AND FROZEN VEGETABLES	64	8	56			
51 FOREST PRODUCTS, NEC	42	42				
51 CLAY	2,548		2,548			
34 VEGETABLES AND PREP, NEC	3		3			
42 PREPARED ANIMAL FEEDS	23		23			
49 GRAIN MILL PRODUCTS, NEC	2,478		2,478			
31 ALCOHOLIC BEVERAGES	85	85				
91 VEGETABLE OILS, MARG, SHORT	551		551			
99 MISCELLANEOUS FOOD PRODUCTS	60		60			
11 BASIC TEXTILE PRODUCTS	20		20			
11 FURNITURE AND FIXTURES	14		14			
11 PULP	1,342		1,342			
31 PAPER AND PAPERBOARD	35,193		34,136			1,057
11 PRINTED MATTER	4		4			
10 SODIUM HYDROXIDE	1,200				1,200	
19 BASIC CHEMICALS AND PROD, NEC	2,733		75		2,658	
21 PLASTIC MATERIALS	483		483			
41 SOAP	26		26			
61 GUM AND WOOD CHEMICALS	3,756		3,756			
91 MISCELLANEOUS CHEMICAL PROD	64	1	63			
15 RESIDUAL FUEL OIL	497,806	43,235		264,450	26,387	163,734
11 RUBBER AND MISC PLASTICS PROD	16		16			
11 GLASS AND GLASS PRODUCTS	37		37			
91 MISC NONMETALLIC MINERAL PROD	24		24			
19 IRON AND STEEL PRODUCTS, NEC	4		4			
11 MACHINERY, EXCEPT ELECTRICAL	25		25			
11 INSTR, TIME, PHOTO, OPT GOODS	6		6			
11 MISC MANUFACTURED PRODUCTS	190		190			

TOTAL TON-MILES, 4,793,929.

ECTION 2.

TRIPS AND DRAFTS OF VESSELS

RBOR OR WATERWAY	DIRECTION											
	SELF PROPELLED VESSELS			NON SELF PROPELLED VESSELS			SELF PROPELLED VESSELS			NON SELF PROPELLED VESSELS		
DRAFT (FEET)	PASSENGER AND DRY CARGO	TANKER	TOWBOAT OR TUGBOAT	DRY CARGO	TANKER	TOTAL	PASSENGER AND DRY CARGO	TANKER	TOWBOAT OR TUGBOAT	DRY CARGO	TANKER	TOTAL
T ST. JOE HARBOR, FLA.				INBOUND						OUTBOUND		
34		3				3						
33		2				2						
32		1				1						
31		3				3		2				2
30		5				5						
29		1				1	1					1
28							2	1				3
27	2					2	4					4
26	3					3	2	1				3
25	2					2	4					4
24	1					1	4	4				8
23	2	1				3	1	5				6
22	2					2	1	3				4
21	2					2		1				1
20	3	2				5		1				1
19	1					1	1	1				2
18 AND LESS	3	1	49	27	72	152	1		49	27	72	149
TOTAL	21	19	49	27	72	188	21	19	49	27	72	188

Source: Waterborne Commerce - 1974

verified and the shipment of Residual fuel oil to Port St. Joe governs the project depth of this waterway in the range 30 ft. through the entrance project depth of 37 ft. The cumulative Federal costs of this project since 1962 have been in excess of $3M (to 6/73). (21) Regional alternatives to the shipment of this cargo to Port St. Joe should be considered. If an alternative means of receipt of this cargo is forthcoming, a decrease in project depth to 30 ft. seems appropriate with a resulting Federal savings.

A similar procedure for the determination of "deep-draft" cargoes and their relationship with project depth has been carried out for the remainder of the waterways of Table 4.3. The results as shown in Table 4.5 are sparse and inconclusive. For only two of the thirty waterways considered was a relationship identified between project depth and "deep-water" cargoes. The breakdown of the statistics in Waterborne Commerce does not provide the necessary detail to permit the matching of a principal dry-bulk cargo with the draft of its carrier. The column headed "Passenger and Dry Cargo" in Section 2 aggregates the trip and draft information for a variety of carriers including: break-bulk, combined bulk, bulk, container and passenger vessels. Where P&DC vessels transit at or near the project depth, their cargoes cannot be deduced without detailed local information. This dilemma, as previously encountered with St. Petersburg Harbor, occurred for the remaining twenty-eight waterways. Crude oil and petroleum products were, however, identified as "deep-draft" cargoes when carried in tankers for twenty-six of the waterways. These two groups governed the project depth (in consort with other unidentifiable cargoes) in all save two of the Mobile, New Orleans and Galveston district waterways. As such, the verification of a causal relationship for these waterways was judged indefinite as additional information might

TABLE 4.5

DEEP-DRAFT CARGOES OF THE GULF COAST REGION

WATERWAY	DEEP-DRAFT CARGOES	CAUSAL RELATIONSHIP IDENTIFIED	RANGE	COMMENTS
ST. PETERSBURG	UNKNOWN - P+DC AND TOWBOAT CARGOES	NO		REQUIRE ADDITIONAL INFORMATION
TAMPA	UNKNOWN - TANKER CARGOES	NO		
PORT ST. JOE	RESIDUAL FUEL OIL - TANKER	YES	30'-37'	
PANAMA CITY	UNKNOWN - PROBABLE PULP AND SCRAP	INDEFINITE		REQUIRE ADDITIONAL INFORMATION
PENSACOLA	CRUDE OIL AND PRODUCT - PROBABE GRAIN			
MOBILE	PROBABLE GRAIN, ORE, COAL			
PASCAGOULA	PROBABLE GRAIN, PHOSPHATE			
GULFPORT	UNKNOWN - PROBABLE GRAIN, BANANA			
INNER HARBOR NAV. CANAL	PETROLEUM PRODUCT AND UNKNOWN	NO		MULTIPLE COMMODITIES APPEAR TO BE SHIPPED NEAR P.C.
M.R.G.O.		NO		
CALCASIEU RIV. & PASS	CRUDE OIL AND PRODUCT; PROBABLE GRAIN, SCRAP, COKE	INDEFINITE		REQUIRE ADDITIONAL INFORMATION
BATON ROUGE	PROBABLE GRAIN, ORE, COAL			
NEW ORLEANS				
SABINE-NECHES WTRWY.				
HOUSTON				
TEXAS CITY CHANNEL		YES	33'-40'	
GALVESTON	PROBABLE GRAIN, ORE	INDEFINITE		REQUIRE ADDITIONAL INFORMATION
FREEPORT	PROBABLE GRAIN, ORE, COAL			
MATAGORDA SHIP CH.				
CORPUS CHRISTI SH. CH.				
HARBOR ISLAND				
BRAZOS ISLAND				
BROWNSVILLE				

lead to identification of the remaining "deep-draft" cargoes.

The results of Table 4.5 have been called sparse for without additional local information, a detailed study of regional alternatives may only be undertaken for Port St. Joe and the Texas City Channel. For such a small sampling of the Region's waterways, efforts would degenerate to local issues. An effort will be made in the following section to pursue the generation of regional alternatives to dredging based on the below premises that have been developed:

1) The majority of ocean-going tonnage transiting the Gulf Coast region is attributable to a select few dry and liquid bulk cargoes.

2) Several waterways of the Region have become specialized in the transfer of one or two cargo groups which alone account for a significant percentage of ocean-going tonnages.

3) Project depths have been found to be governed by one or two cargo groups in the case of two waterways and may be governed by the shipment of less than five cargoes in the majority of the waterways considered.

4) The shipment of crude oil and petroleum products in tankers exerts an influence on project depths for twenty-six of the thirty waterways considered.

The generation of regional alternatives to dredging will be pursued in light of alternately satisfying the shipment needs of crude oil and petroleum products. This will predominately concern the waterways of the New Orleans and Galveston districts where all project depths are influenced by these two cargoes.

4.2 Regional Alternatives to the Shipment of Crude Oil and Petroleum Products

Additional detailed information is required to identify all

the deep-draft cargoes that have governed the setting of project depths for the Gulf Coast Waterways. The collection of this information may indeed prove costly. Therefore, a conceptual development of alternatives to dredging based on available information is warranted to investigate the worth of future expenditures. Such an effort will be pursued based around the shipment of crude oil and petroleum products in the Gulf region. Of the thirty waterways previously considered, one or both of these cargoes was carried and overall account for greater than 50% of the region's ocean-going tonnage. The carriage of these two cargoes on waterways whose total tonnage (1974) exceeds 1M s.t. has been recorded on Table 4.6. Gasoline, jet fuel, kerosene, distillate fuel oil and residual fuel oil have been included in the petroleum product grouping. As a region it is seen that the Gulf Coast is a net importer of crude oil and a net exporter of petroleum products. Specifically, 67M s.t. of foreign crude oil were imported, 14M s.t. of crude oil was exported coastwise, 9M s.t. of foreign petroleum products were imported, and 51M s.t. of petroleum products were exported. Some waterways received crude oil and petroleum products from coastwise sources, but these shipments may be considered intraregional. The exports of these two cargo groups to foreign destinations is negligible. Collectively, the Gulf Coast waterways perform the following regional services (vessel size as per Table 4.2):

1) Importation of foreign crude oil from:

Eastern Hemisphere:	45K - 62K DWT tankers
Caribbean:	20K - 45K DWT tankers

TABLE 4.6

OCEAN-GOING PETROLEUM SHIPMENTS ON THE GULF COAST WATERWAYS

(millions s. tons)

WATERWAY	TOTAL CARGO THROUGHPUT	REGIONAL RECEIPTS				REGIONAL SHIPMENTS			
		FOREIGN CRUDE	COASTWISE CRUDE	FOREIGN PRODUCT	COASTWISE PRODUCT	FOREIGN CRUDE	COASTWISE CRUDE	FOREIGN PRODUCT	COASTWISE PRODUCT
TAMPA*	41			2.8	7.3				0.4
PANAMA CITY*	2			0.2					0.02
PENSACOLA	2	0.2			0.2				
MOBILE	33	0.02		0.02	0.4	0.1	33		
PASCAGOULA	13	1.4		0.15	0.35				2.4
INNER HARBOR NAV. CANAL	25	NIL	NIL	NIL	NIL				
M.R.G.O.*	3.4	NIL	NIL	NIL	NIL				
CALCASIEU RIVER & PASS	16.5	1.8		0.25	0.35		0.5		1.2
BATON ROUGE (B.R.)	54	3.8	0.05	0.07	0.3		0.5		4.0
NEW ORLEANS (N.O.)	144.2	4.3	0.03	1.5	0.3	NIL	4.0	NIL	5.3
MISS. RIVER B.R. to N.O	186	14.2	0.07	0.5	0.9		0.6		8.0
MISS. RIV. N.O. to PASSES	193.4	3.6	0.27	1.1	0.25	NIL	4.0	NIL	1.32
BEAUMONT	33.5	5.9	0.33	0.08	0.22		3.3		5.8
PORT ARTHUR	27.8	7.3	2.6	0.4	0.9			NIL	7.4
HOUSTON SHIP CHANNEL	87.1	10.8	2.3	1.1	0.9		1.8	NIL	15.3
TEXAS CITY CHANNEL	20.2	2.5	0.03	0.1	0.03		0.2		3.5
GALVESTON	7.2	2.0							
FREEPORT	8.9	1.5	0.5	NIL	0.03				0.5
MATAGORDA SHIP CHANNEL	4.9							0.05	
HARBOR ISLAND	5.4	2.1	0.07				0.8		0.1
CORPUS CHRISTI HARBOR	32.8	6.1	0.3	0.1	0.2		1.2	0.09	8.2
BROWNSVILLE	2.8	0.25		0.1			0.03	0.03	0.15
TOTAL	929	65.97	9.72	8.97	14.23	0.1	23.8	0.17	64.91
NET		CRUDE OIL = 65.87		PRODUCT = 28		CRUDE OIL = 13.86		PRODUCT = 56.8	
NET/NET		FOREIGN CRUDE OIL = 53				COASTWISE PRODUCT = 42			

*THESE ARE "CONSUMER PORT" AREAS IN ADDITION TO:

ST. PETERSBURG, FLA.
PORT ST. JOE, FLA.
THREE MILE CREEK, ALA.
GULFPORT, MISS.

SOURCE: WATERBORNE COMMERCE, 1974

2) Exportation of crude oil via:
   Coastal Routes: 15K - 35K DWT tankers

3) Importation of foreign petroleum products from:
   Caribbean: 28K - 32K DWT tankers

4) Exportation of petroleum products via:
   Coastal routes: 15K - 25K DWT tankers

All or part of these services are performed by no less than seventeen Gulf ports and over numerous waterways originally considered (Table 4.3), nine are concerned only with the importation or redistribution of petroleum products and act as "consumers". The remaining "producers" or waterways importing crude and supplying petroleum products for regional export continue to account for 94% of the total ocean-going tonnage of these two cargoes. These producing waterways, not surprisingly, serve areas in the region where petroleum refineries are concentrated. The scope of concern for the generation of alternatives will consequently be reduced to the Mobile, New Orleans and Galveston districts wherein virtually all refining capacity within the region lies.

The provisions of the Deepwater Port Act of 1974 seek to maximize transport savings while minimizing oil pollution and shipping casualties for the shipment of crude oil and its products. The concept of an offshore deepwater petroleum port, is also attractive when viewed as an alternative to dredging. The Act (Sec. 4. (c)) while designating ten criteria for the approval decision, including cost and environmental impact, fails to address this viewpoint. Neither the Act nor the resulting Regulations (1) require an assessment of such a terminal's effect on the present traffic or cargo carriage of the surrounding

waterways. None of the four active Gulf Coast deepwater port studies (Mobile, La Fourche, Freeport and Corpus Christi) have published any design considerations for the transfer of petroleum products. The importation of crude oil in VLCC carriers is the sole thrust of these studies. Economies to scale are present in the shipment of petroleum products in coastal tankers and have been documented by the Department of Transportation. (14) The applications of LOOP, Inc. (La Fourche, La.) and SEADOCK, Inc. (Freeport, Tx.) for off-shore deepwater ports briefly touch on the impact of these proposed facilities on the surrounding port areas. Both applications in computation of their "highest throughput case" for crude oil assume that all imports will flow through the proposed facilities. Such an occurrence would remove all foreign crude oil bearing tankers from the region's waterways. However, both applications discount the occurrence of this event in the short run. The application of SEADOCK, Inc. proposes that should a reduction in crude-bearing traffic occur in coastal ports, it would likely be offset by an increase in shipments of refined product.

The scope of regional alternatives to dredging through the transport of crude oil and petroleum products will be finally narrowed to the areas of influence of the proposed deepwater ports at Bayou La Fourche, La. and at Freeport, Tx. The influence areas for the Mobile, Ala. and Corpus Christi, Tx. deepwater proposals might also be considered. However, the degree of detail as well as the prospect for completion of these two sites is far inferior to that of LOOP and SEADOCK. The proposed location and area of influence for the Galveston

and New Orleans district deepwater ports are shown in Figure 4.1. The areas of influence for both proposals were derived from the information supplied in the applications to the U. S. Coast Guard. These areas are based on the refining centers, listed in Table 4.7, that are expected to be served by the terminals. It is anticipated that the LOOP facility will actually supply crude oil to refineries well into the states of Indiana, Illinois, Kentucky, Ohio, Minnesota, and New York via the Capline Crude oil pipeline. However, only those refineries located in the Gulf coastal states will be considered. LOOP is expected to supply crude oil to refineries which represent 83% of the total major refining capacity in Louisiana east of Lake Charles. (19) It is anticipated that approximately 57% of the major refining capacity will be served by SEADOCK within its influence area. (18) The combined influence areas cover all the fifteen ocean-going waterways between the Passes of the Mississippi River and the Matagorda Ship Channel. It will be assumed whether through economic incentive or public policy decision that all inbound foreign crude oil will pass through these two facilities with the required pipelines contracted as necessary. This will significantly reduce the inland heavy-laden tanker traffic on the waterways within the area. The remaining tanker traffic will be comprised of inbound coastwise crude oil and outbound regional shipments of petroleum products. These shipments as previously indicated, will continue to sustain project depths at their present levels. The following alternatives to dredging based around the shipments of these cargoes are forthcoming, (for the present ignoring the effect on other "deep-draft cargoes"):

Figure 4.1. Influence Areas of Proposed Deepwater Ports.
Source: USACOE, Report on Gulf Coast ...(8)

TABLE 4.7

GULF COAST REFINERIES TO BE SERVED BY THE PROPOSED DEEPWATER PORTS

I. LOOP

1. ECOL ltd., Garyville, La.
2. Exxon Co., Baton Rouge, La.
3. Murphy Oil Co., Meraux, La.
4. Shell Oil Co., Norco, La.
5. Tenneco Oil Co., Chalmette, La.

Source: LOOP Application (19)

II. SEADOCK

1. Crown Central Pet. Corp., Houston, Tx.
2. Exxon Co., Houston, Tx.
3. Gulf Oil Corp., Port Arthur, Tx.
4. Mobil Oil Corp., Beaumont, Tx.
5. Phillips Petroleum Co., Sweeney, Tx.
6. Shell Oil Co., Deer Park, Tx.
7. Cities Service Oil Co., Lake Charles, La.
8. Continental Oil Co., Lake Charles, La.

Source: SEADOCK Application (18)

1) Reduction of project depths on all waterways in the area. The average size of a fully laden tanker now transporting crude and petroleum products is 50,000 DWT at a draft of approximately 40 ft. If project depths were reduced to 35 ft., tanker size would necessarily be reduced to approximately 35,000 DWT. The result would be increased transport costs and therefore regional prices on imports. If the demand for these products is relatively inelastic over the range of price differential, then increased tanker traffic would result. However, the presence of elastic demand would result in decreasing regional revenues on exports.

2) Selective reduction of project depths perhaps based on their proximity to the deep-water terminals. Some cost increase for cargo transport might be expected as with the first alternative. These costs might be off-set by increased tanker traffic to those water-ways unaffected by a depth reduction.

3) Reduction of project depth on all waterways and expansion of the offshore deepwater terminals capability to transfer these cargoes. This alternative would effectively remove all petroleum traffic from the areas waterways. The average size of carrier tankers might in-crease to 60K - 70K DWT, with a resulting decrease in water transport costs. Such an alternative's benefits must be balanced against the increased construction and second-ary distribution costs.

The latter alternative is chosen for a more detail development. While offering the same potential savings in dredging cost as the first alternative, the latter proposals appear to capitalize on many of the same economic and ecological advantages as an off-shore deepwater crude oil terminal.

CHAPTER 5

DEVELOPMENT OF AN ALTERNATIVE

5.0 Conceptional Design of a Deepwater Petroleum Product Terminal

The development of an offshore deepwater petroleum product terminal will be undertaken in three phases. The throughput of the terminal will be estimated and a preliminary design of the facility to support this volume will be accomplished. Secondly, the costs and savings of the concept will be evaluated from a regional and national viewpoint. The economic worth of the proposed facility will finally be evaluated for value to an operator. The conceptual design necessarily will be made around certain assumptions. The sensitivity of the economic worth of the terminal to a change in these assumptions will also be established.

The volume or throughput of petroleum products at an off-shore terminal dictates pumping, distribution and storage capacities. Present flows of product into the influence areas of LOOP and SEADOCK have been recorded for 1974 on Table 5.1. Residual fuel oil and heavier products have been excluded as these products at present are not commonly piped over long distances. (14) The results of Table 5.1 indicate that the waterways within these influence areas account for the shipment of 0.35M barrels per day (B/D) and 0.66M B/D of products, respectively. These throughputs are based on both inbound and outbound coastwise shipments with outbound tonnage accounting for 90% of the total. As previously mentioned, the operation of a crude oil deepwater terminal may induce increased

TABLE 5.1

INFLUENCE AREAS' OCEAN-GOING PETROLEUM SHIPMENTS

(1,000 s. tons)

WATERWAY	REGIONAL IMPORTS								REGIONAL EXPORTS			
	FOREIGN COMMERCE				COASTWISE COMMERCE				COASTWISE COMMERCE			
	GASOLINE	JET FUEL	KEROSENE	DISTILLATE FUEL OIL	GASOLINE	JET FUEL	KEROSENE	DISTILLATE FUEL OIL	GASOLINE	JET FUEL	KEROSENE	DISTILLATE FUEL OIL
DOOR AREA												
INNER HARBOR NAV. CANAL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
M.R.G.O.	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
BATON ROUGE (B.R.)	36			26	197			318	1,256	322	106	1,710
NEW ORLEANS (N.O.)	21		88	306	41			17	2,550	296	191	1,167
MISS. RIVER B.R. to N.O.	65		12	142	202			385	3,454	601	280	2,603
MISS. RIV. N.O. to PASSES	21		76	190	36				353	17	19	280
SUB TOTAL	143	0	176	664	476	0	0	720	7,613	1,236	596	5,760
NET (s. tons)	GASOLINE = 8,232 JET FUEL = 1,236 KEROSENE = 772 DISTILLATE = 7,194											
NET (M B/D)	GASOLINE = 0.182 JET FUEL = 0.025 KEROSENE = 0.015 DISTILLATE = 0.128 / TOTAL = 0.35											
SEADOCK AREA												
LAKE CHARLES	111			114	183			141	591	114	15	257
BEAUMONT	16			67	17		15	111	3,198	426	144	1,868
PORT ARTHUR	202		101	94	354	30		126	2,815	693	22	2,025
HOUSTON SHIP CHANNEL	85		211	165	166	35		320	755	648	543	5,546
TEXAS CITY CHANNEL	61				4			26	2,087	20	113	981
GALVESTON												
FREEPORT	16				3			26	379		2	219
SUB TOTAL	491	0	312	410	727	65	15	750	16,626	1,881	839	10,857
NET (s. tons)	GASOLINE = 17,644 JET FUEL = 1,946 KEROSENE = 1,166 DISTILLATE = 12,077											
NET (M B/D)	GASOLINE = 0.394 JET FUEL = 0.037 KEROSENE = 0.022 DISTILLATE = 0.215 // TOTAL = 0.67											

MEAN SPECIFIC VOLUME OF PETROLEUM	CRUDE OIL	GASOLINE	JET FUEL		
	6.6 BBL/l.t. ton	7.94 BBL/s.ton	7.2 BBL/s.ton	6.9 BBL/s.ton	6.4 BBL/s.ton
	7.4 BBL/l.t. ton	8.9 BBL/l.t. ton	8.05 BBL/l.t. ton	7.82 BBL/l.t. ton	7.2 BBL/l.t. ton

SOURCE: WATERBORNE COMMERCE, 1974

product shipments within an influence area. It would be a most complicated and perhaps cost prohibitive matter to design a "two-way" deepwater product terminal capable of both receiving and loading cargo. It will be assumed within an influence area that an offshore crude oil terminal will replace the need for the receipt of petroleum products. Therefore, a product terminal need only be capable of shipping such cargoes. Additionally the assumption is made that all shipments of ocean-going petroleum products in the influence area will be made from the deepwater terminal. Future growth in throughput will therefore be based upon the 1974 volumes. Future throughput will most definitely be affected by the continued importation of product and shipments from adjacent port areas. Therefore, the level of throughput will be addressed in a sensitivity analysis. The site selection process for an offshore facility involves a myriad of economic, environmental and social factors. SEADOCK and LOOP have conducted extensive research in the siting of their respective deepwater crude oil terminals. It will therefore be assumed that prospective product terminals will be constructed directly inshore from these crude oil terminals. This will facilitate the use of local cost estimates that were developed at these sites. Finally, the product terminals will be planned for construction in 1979 and operation in 1980 to coincide with the schedule of the crude oil terminals. Each product facility will be capable of receiving 50K DWT tankers in 1980 with an ultimate capability of up to 70K DWT tankers. The facilities will be located 10 miles offshore in 60 ft. of

water in the vicinity of the crude oil terminals as shown in Figure 5.1. A flow chart has also been provided to demonstrate the integration of the major components of the facilities. The characteristics of each facility are as follows:

	LOOP	SEADOCK
1. Economic Life (yrs.)	25	25
2. Throughput (1000 B/D)		
Initial	400	700
Ultimate	625	1090
3. Terminal Type	(2) Berth Fixed Pier	(2) Berth Fixed Pier
4. Carrier Vessel Size (DWT)		
Initial	50,000	50,000
Ultimate	70,000	70,000
5. Distance Offshore (s. miles)	10	10
6. Depth of Water (ft.)	60	60
7. Pumping Capabilities	Transfer Onshore	Transfer Onshore
8. Storage Characteristics		
Capacity	7 days	7 days
Tank Size (1000 BBL)	800	800
Type of Tanks	Floating Roof	Floating Roof
Distance from Terminal (mi)	10.5	10.5
9. Refinery Centers Served - overland distance (s. miles)	New Orleans to Baton Rouge - 75 Lower Mississippi River - 50	Houston - 60 Galveston - 20 Sabine-Neches - 115 Lake Charles - 150

A fixed pier terminal has been chosen in lieu of a jetty or sea-island concept due to its lower initial expense. The Single

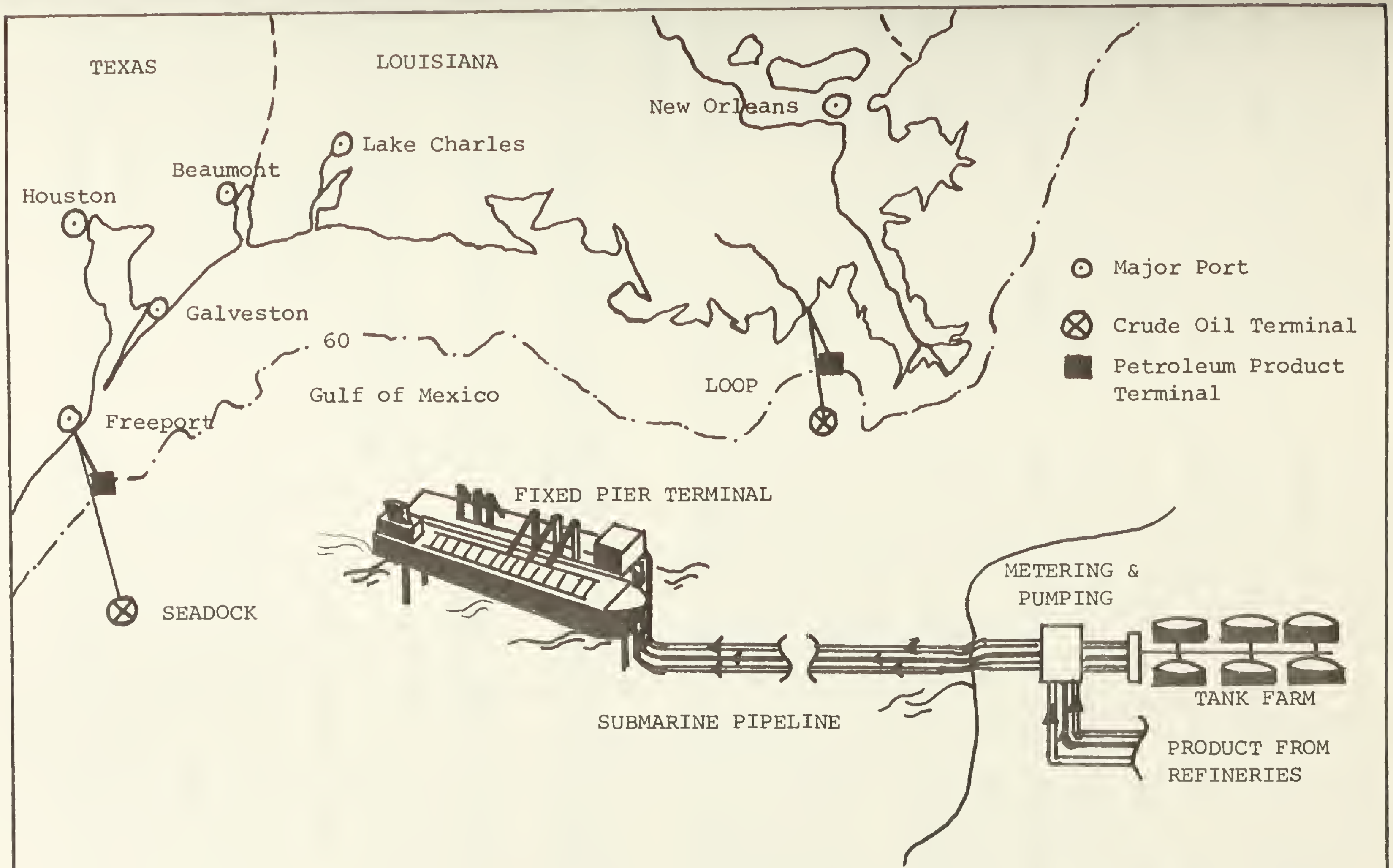


Figure 5.1. Location and Major Components of Offshore Petroleum Product Terminals

Point Mooring concept was not considered due to its inability to efficiently transfer more than one product simultaneously. Based on these desirable characteristics a preliminary cost estimate was performed as presented in Appendix C. The major component costs for each facility are summarized in Table 5.2. Delivery piping costs estimates from the principal refining centers to the terminals have also been made. The delivery system costs would not be expected to be borne by the owners of the product terminals, but are provided for informational purposes. Provisions have been made in these estimates for the upgrading of both terminals to serve 60K DWT tankers in 1990 and for 70K DWT tankers by the year 2000.

The regional value of these facilities is the sum of their economic, environmental and social values. The construction and operation of a product terminal might affect the region's economy, as follows:

1) An increase in regional employment and revenues due to the construction, operation and maintenance of the new terminal.

2) A decrease in local employment and revenues at present inshore petroleum terminals.

3) Loss of capital investment in inshore petroleum product terminals.

4) A decrease in the cost of shipping petroleum products.

The major positive environmental impacts might be a reduction of oil pollution on the waterways and a reduction in marine vehicle casualties. However, if a significant increase in petroleum and petrochemical industries is induced, a

TABLE 5.2a

ESTIMATED CONSTRUCTION COSTS OF AN OFFSHORE PETROLEUM PRODUCT TERMINAL - LOOP AREA

($'s MILLIONS)

COST	1980	1990	SUB TOTAL
THROUGHPUT (1000's BBL)	400	480	
OFFSHORE FACILITY:			
FIXED PIER TERMINAL	35	9	44
SUBMARINE PIPELINES			
(2) 30" - 10.5 miles	12		12
(1) 8" - 10.5 miles	2		2
(1) 30" - 10.5 miles		8	8
TOTAL MARINE FACILITY	49	17	66
ONSHORE FACILITY:			
LAND, PIPE, BUILDINGS, TANKS, ETC.			
(4) 800K BBL TANKS	24		24
(2) 800K BBL TANKS		16	16
TOTAL ONSHORE FACILITY	24	16	40
ONSHORE DISTRIBUTION SYSTEMS			
SEE APP. C-1 FOR DETAILS	10		10
GENERAL ORGANIZATIONAL:	11	5	16
TOTAL	94	38	132
TOTAL (LESS DISTRIBUTION)	84	38	122

Source: App. C-1

TABLE 5.2b

ESTIMATED CONSTRUCTION COSTS OF AN OFFSHORE

PETROLEUM PRODUCT TERMINAL - SEADOCK AREA

($'s MILLIONS)

COST	1980	1990	SUB TOTAL
THROUGHPUT (1000's BBL)	700	850	
OFFSHORE FACILITY:			
FIXED PIER TERMINAL	40	11	51
SUBMARINE PIPELINES:			
(2) 36" - 10.5 miles	16		16
(1) 8" - 10.5 miles	2		2
(1) 36" - 10.5 miles		9	9
TOTAL MARINE FACILITY	58	20	78
ONSHORE FACILITY:			
LAND, PIPE, BUILDINGS TANKS, ETC.			
(7) 800K BBL TANKS	42		42
(3) 800K BBL TANKS		24	24
TOTAL ONSHORE FACILITY:	42	24	66
ONSHORE DISTRIBUTION SYSTEM:			
SEE APP C-1 FOR DETAILS	33		33
GENERAL ORGANIZATIONAL:	15	6	21
TOTAL	148	50	198
TOTAL (LESS DISTRIBUTION)	115	50	165

Source: App. C-1

degradation in air quality may follow. An important social impact which might occur is the redistribution of population to support new industrial complexes locating in the vicinity of the deepwater ports. A detailed environmental impact statement would be the vehicle to fully assess the effect of such a terminal's presence. This conceptual design will, however, be directed towards the regional and national economic benefits which may be forthcoming from the shipment of petroleum products from a deepwater terminal to other areas of the nation. Figure 5.2 depicts the transportation costs associated with the shipment of product in tankers ranging from 26K to 70K DWT. These curves have been approximated from the Dept. of Transportation study referred to earlier. (14) For the computation of transport cost comparisons, shipment of petroleum product in a 30K DWT tanker over 1500 s. miles, was selected as the base case. The following transport costs were used:

30,000 DWT tanker for 1500 miles = $0.47/BBL
50,000 DWT tanker for 1500 miles = $0.37/BBL
60,000 DWT tanker for 1500 miles = $0.34/BBL
70,000 DWT tanker for 1500 miles = $0.30/BBL

Therefore, the shipment of petroleum products from a deepwater terminal might be expected to yield savings of $0.10, $0.13, and $0.17 for every barrel of product shipped in 50K, 60K, and 70K DWT tankers, respectively; rather than in 30K DWT tankers. The "net present value" (NPV) of these transport savings and the

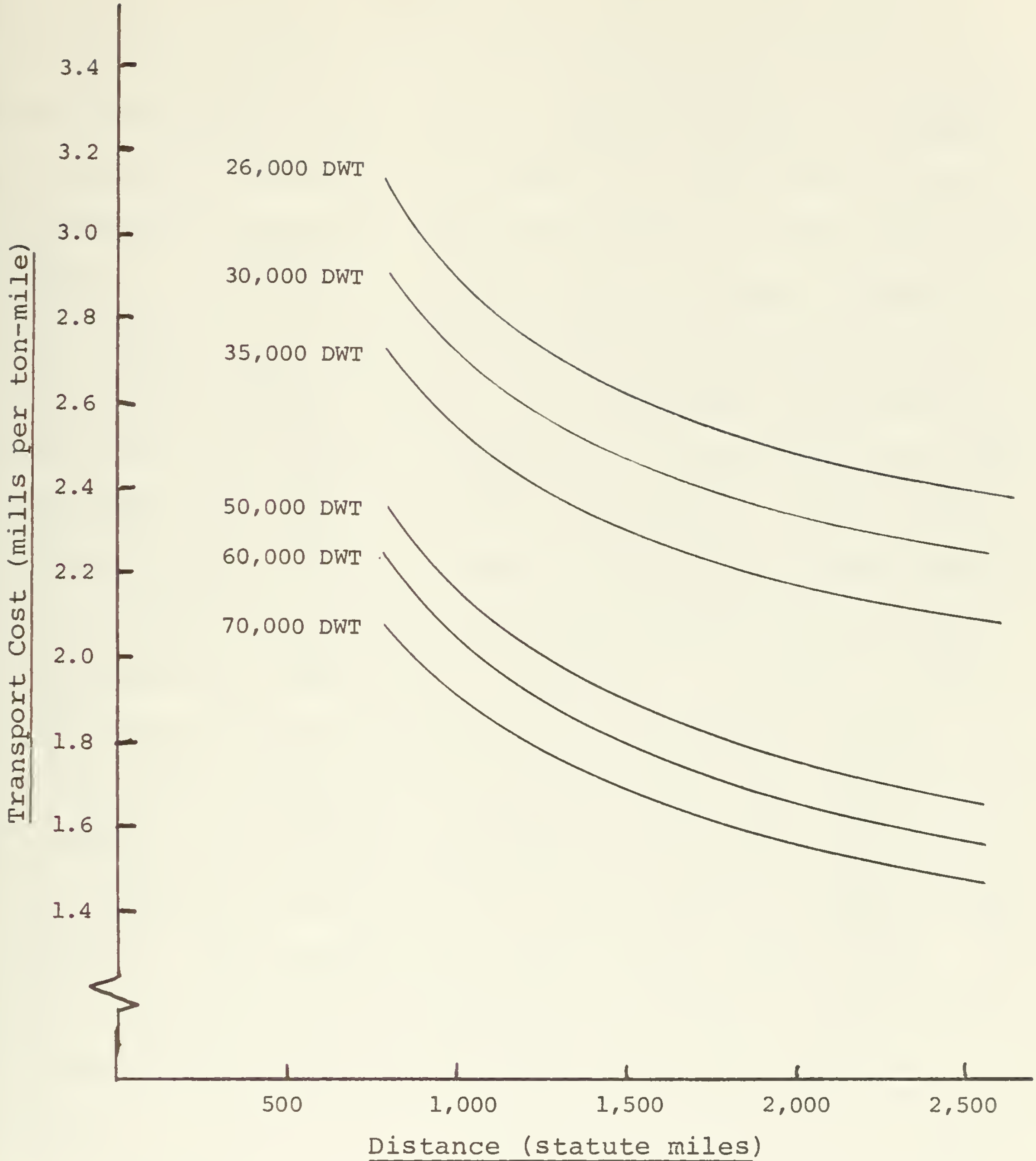


Figure 5.2. Transport Cost Curves for Intercoastal U.S. Flag Petroleum Tankers. Source: D.O.T., Economic Aspects of Refinery...(14)

previous construction costs have been computed in Appendix C. Additional savings in dredging costs may only be realized through public policy decision. Even with all crude oil and petroleum product tanker traffic removed, dry-bulk shipments will continue to transit at or near the project depth of the influence area waterways (with the exception of the Texas City Channel). A reduction in project depth on those waterways might significantly affect the economics of transport of the remaining "deep-draft" cargoes. As previously indicated the desirability and extent of reduction in project depth may only be assessed with additional local information. However, the dredging savings resulting from a reduction in projects depth of 3 ft. and 7 ft. have been estimated and the present value of the terminals calculated in Appendix C. Finally, an estimate of cash flows to the operator of a deepwater product terminal over a 25-year life span have been made. To attain 15% return on the initial investment, an estimate of a tariff to be charged by the facility for the transfer of product was necessary. The resulting net present value (NPV) of the project to an operator is recorded in Appendix C. The major findings of the analysis are summarized on the page that follows.

1) The estimate of terminal throughput and its growth rate is the predominant design factor directing the sizing of all major components and ultimately the cost and profitability of the terminal. Originally a growth rate of 3% per annum had been used to predict throughput to 2004 in line with the growth in domestic demand for crude oil over the past decade. However, more recent predictions for the demand in imports and exports of refined products suggest a 2% per annum growth through the year 2000 and 1% per year thereafter. (31) These latter growth rates were therefore utilized.

2) The NPV's for transport savings less construction, maintenance and operating expenditures at an assumed discount rate of 12% are \$5M and \$60M for the LOOP and SEADOCK areas, respectively (over a 25-year life cycle). The projects appear warranted from a national standpoint. However, when the construction costs for the distribution pipeline systems are included the NPV's are reduced to -\$5M and \$28M, respectively. Therefore the terminal for the LOOP area under these conditions is only warranted from a national standpoint if the cost of a distribution pipeline is limited to less than \$5M. These same costs for the SEADOCK area terminal appear less restrictive and up to \$60M may be expended with all other factors held constant.

3) The NPV's of the projects increase by an average \$20M when accompanied by a 3 ft. reduction in project depths on the ocean-going waterways within the influence areas. A 7 ft. reduction in project depth produces an average \$35M increase in NPV for the facilities. The added NPV for a 3 ft. reduction in project depth is equivalent to an average savings of \$2.6M per year and \$4.5M per year for a 7 ft. reduction. With an average annual dredging maintenance expenditure of approximately \$27M for the Gulf Coast region (20) the combined effect of a 3 ft. reduction would be a 19% savings and a 34% savings in dredging expenditures for a 7 ft. reduction.

4) The NPV of the offshore product facilities based on discounted (12%) revenues less investments and operating expenses exceeds \$25M for an operator. To generate revenues, a tariff for the transfer of product would be imposed. The average tariffs for the facilities are \$0.15/BBL (LOOP area) and \$0.12/BBL (SEADOCK area) to insure a minimum return on assets of 15%. These loading tariffs appear consistent with those assessed by private oil port facilities whose tariffs range from \$0.10/BBL to \$0.20/BBL. The transfer tariffs at public oil facilities are considerably higher and range from \$0.20/BBL to \$1.00/BBL. (18) Therefore, the facilities appear competitive for the loading and water transport functions. The competitive position of these

> facilities will ultimately depend upon the cost of delivering product from a refinery to the terminal. This on-land pipeline delivery cost would be beyond the control of the terminals and determined by the control of the terminals and determined by the capabilities of the shipper. The costs must, however, be investigated in a more detailed design stage.

The higher tariffs necessary for the LOOP area deepwater product terminal suggest the presence of economic to scale with increasing levels of throughput as attained by the SEADOCK facility. However, the larger burden imposed on the LOOP facility is undoubtedly influenced by the manner in which maintenance and operational costs were determined for each facilty.

The results of the preceding analysis appear to support the economic value and competitive position of the concept of a petroleum product deepwater shipment terminal. However, these results are totally dependent upon the assumptions previously made. The variance of economic value with changes in these assumptions will be explored in the following section.

5.1 Sensitivity Analysis

The net present value (NPV) of the proposed terminal has been calculated in Appendix D for changes in the design variables and assumptions. The results summarized below are as noted for the SEADOCK area terminal. The change in NPV for each percentage change of the variable assumed has been noted to identify those

variables most critical to the value of the project.

1) Initial Throughput Level (B/D): is a function of the market that the facility can effectively capture with the commencement of operations. In 1974 the sum of all shipments and receipts of "pipeable" petroleum products within the SEADOCK influence area has been identified as 660,000 B/D. A value of 700K B/D has been assumed for the initial facility throughput in 1980. The actual level attained in 1980 will be influenced by public policy decisions, the perceived economic incentives of the facility, the state of the economy, etc. The assumed initial level was varied from 350K B/D to 1,050K B/D with the resulting NPV's changing from a -$96M to $147M producing the largest range in value of all (save one) of the variables considered. If a linear change in NPV is assumed within this range of throughput, a $2.4M change in NPV is experienced for every 1% change from the assumed level of throughput, increasing with increasing throughput. Sensitivity = +$2.4M/% change.

2) Transport Savings ($/BBL): are a function of transport tanker characteristics including deadweight tonnage, degree of loading, manning, receiving ports characteristics, length of route, etc. The savings assumed as presented in Fig. 5.2 were based on three vessel sizes and a route length of 1,500 statute miles. Savings were varied by50% of their assumed values. With the length of route held constant, NPV's varied in the same manner as the throughput level above. Sensitivity = +$2.4M/% change. Additionally, an NPV of only $2M results when transport savings are calculated for shipments in 50K DWT tankers throughout the terminal's life. It would appear that it is desirable that the terminal serve 60K DWT tankers during its life cycle.

3) Discount Rate (%): for a private enterprise is defined as the weighted average cost of capital to that company. The discount rate for public works projects is established by Congress. The private discount rate is a function of a companies' debt structure, the interest rate demanded by debtors, the expectations of investors, etc. A value of 12% has been assumed and allowed to vary from 7% to 16%. The resulting NPV for these changes in discount rate ranged from $107M to -$18M, respectively. Sensitivity = - $1.9M/% change.

4) Construction and Improvement Costs: In addition to material costs, construction costs are dependent upon

rights of way, labor rates and availability, weather, technical and environmental restrictions, etc. An initial construction estimate of $115M for a terminal to serve 50,000 DWT tankers was assumed. Additionally, $50M has been allowed for expenditure in 1990 to upgrade the terminals throughput and provide service to 60K and 70K DWT tankers. A $32.7M expenditure in 1980 has also been included for distribution piping. This total investment of $197.7M was varied between $115.2M and $280.2M. The NPV's associated with these changes are $117M and -$68M, respectively. Sensitivity = -$1.85M/% change.

5) Throughput Growth (%/Year): the growth in the shipments of crude oil products from the SEADOCK area terminal depends on much the same variables as the initial throughput level. A growth rate of 2% per year through the year 2000 and 1% per year thereafter was assumed. Growth rates of 1% per year and 3% per year throughout the period were also investigated. The sensitivity of NPV to this variable was considerably less than that of the initial throughput level. NPV's ranged from $50M to $75M. Sensitivity = +$0.25/% change.

6) Maintenance and Operational Costs: these costs were determined as an initial percentage of construction costs and allowed to grow at a constant rate with the age of the terminal. Variances in these costs were found to have the least impact of the variables considered on the NPV of the facility.
Sensitivity: Maintenance = -$0.17M/% change
Operational = -$0.40M/% change

The initial level of throughput, transport savings, discount rate and construction costs have been determined to be the major controlling variables for the economic worth of this conceptual design. The variance in the latter three of these variables may be addressed during the more detailed stages on design. To a certain degree the discount rate and construction cost are controllable by the owner of the facility. A transport survey is in order to confirm transport savings based on vessel size and distance of markets to be served. Of these variables, the initial level of throughput is the least controllable for an owner and

the most potentially damaging variable. With all other variables held constant at their assumed values or rates, a 1980 throughput at the SEADOCK area product terminal exceeding 630,000 B/D must be attained for the national NPV of the project to remain positive. If a 3 ft. reduction in the areas project depths is accomplished, a minimum initial throughput of 560K B/D is sufficient and a minimum of 525K B/D would be required with a 7 ft. reduction in project depths. These conclusions as well as the general results of the sensitivity analysis have presumed mutual independence among the variables considered. This is to say that the NPV has been determined over the range of a single variable while all other factors are held constant at their assumed values. With this approach one may determine those values for the major variables that mark the point where the NPV of a project becomes negative. Design rules may then be specified, as indicated below for the SEADOCK area product terminal, to insure a positive value in the national NPV:

1) Without a reduction in project depths, the initial level of throughput must exceed 630K B/D

2) Transport savings must exceed:

   $0.085/BBL for a 50K DWT tanker
   $0.110/BBL for a 60K DWT tanker
   $0.145/BBL for a 70K DWT tanker

3) The discount rate must not exceed 14%

4) Terminal construction investments must not exceed:

   $130M in 1980
   $ 55M in 1990

5) Distribution pipeline construction costs must not exceed $60M in 1980

While these rules are of value during a preliminary design phase, the distinct probability of more than one variable straying from its assumed value must be addressed. For example, an initial throughput of 650,000 B/D and construction costs of \$125M (1980) and \$55M in 1990 satisfy the above rules. However, with the combination of these two variances, the project is no longer of economic value (NPV=-\$6M). The results of this sensitivity analysis, while identifying the major controlling assumptions, must be applied judiciously in more detailed design work. From a regional and national standpoint, the discount rate is uncontrollable and dependent upon the financial characteristics and financial health of the proposed facility operators. Construction costs and transport savings in addition to being outside the realm of regional and national influence are considered dependent variables. They are dependent upon the initial level of throughput which directs the physical size of the facilities components and the magnitude of transport savings realized.

The expected 1980 throughput may be determined in several ways. Detailed models may be built to forecast such information. These predictions could be buttressed with private industry contracts for committed shipments over a future time span. Both the SEADOCK and LOOP deepwater crude oil proposals have sought to guarantee future throughput in this manner. However, it is the author's opinion that such commitments for future throughput of a product terminal would be extremely difficult to secure. As previously mentioned, the applications

for the offshore deepwater crude oil terminals only briefly dwell upon the impact that such facilities would have upon existing coastal port economies. SEADOCK's application states that present traffic and cargo volumes passing through onshore port areas would be little affected by the new facility. SEADOCK's operation would affect only future increases in tanker traffic with growing new demand. LOOP offers that crude oil volumes flowing into existing port areas may be decreased by that terminal's operation. However, LOOP foresees an increase in volume of refined products which would offset any loss in crude oil volume to existing port areas. Both applicants, understandably, appear to be treading very lightly upon the economic sensitivities of public port authorities, private inshore transhipment terminals and perhaps labor unions. The dependency of the overall ocean-going tonnage in the Gulf region on crude oil and its products has been noted. An offshore facility that would remove a significant portion of this transport traffic and its locally multiplied economic benefits would produce an uproar from onshore port areas. It is for this reason that the author believes that an economically viable offshore product terminal has not been seriously addressed in the past. (Only one such terminal exists in the nation and is located approximately 1.2 s. miles offshore Long Island, N. Y. handling only distillate fuel oils.) (34) Future private commitments to ship petroleum products through an offshore facility would not be readily forthcoming in the face of such opposition by onshore public and private terminal operators. A timely

question is how to promote the economic, environmental and national interest advantages offered by a deepwater product terminal.

A major obstacle appears to be the variance in projected throughput for such a proposed product terminal. A regional or national moratorium on the shipment of ocean-going petroleum products by any means other than from deepwater product ports would accomplish the desired results but is unprecedented. The imposition of waterway user fees would provide some relief to the dredging budget if the proceeds were applied to this proposal. However, all or a portion of these fees may be passed on to the consumer. As product terminals are envisioned as supplying domestic consumers, a rise in domestic prices might be expected. Waterway fees would only indirectly pose an incentive for the shipment of petroleum products through deepwater terminals. There does not appear to be reason to believe that such fees would lessen the actual demand for dredging.

A more direct incentive for the use of deepwater port facilities would be provided by a reduction in project depths on ocean-going waterways. Savings in Federal funds resulting from such a policy stance would further enhance the NPV of offshore deepwater terminals. If a 5 ft. reduction in project depths to an average 35 ft. is accomplished, loaded tankers in general of greater than 35K DWT would be restricted from these waterways. The increased costs that shippers would face in utilizing these lighter vessels in lieu of 50K DWT tankers

provide a \$0.10/BBL (for a 1,500 mile trip) incentive for the usage of an offshore terminal. The environment established by such a public policy stance would be more conducive to the formation of advance commitments for the services of a deepwater product terminal.

5.2 Critique

The foregoing analysis has been directed towards the conceptual design and evaluation of an offshore deepwater petroleum product terminal. The results of this analysis indicate that such facilities are of economic value and would appear to present a competitive challenge to inshore shipment facilities. As an alternative to dredging, the value of such an offshore terminal would be enhanced by a reduction of the surrounding waterway's project depths. However, the change in dredging policy suggested would have serious impact upon the shipment of other deep-draft cargoes. Changes in project depths might only be instituted after other alternatives are explored for the shipment of grain, ore and other deep-draft cargoes within the influence area. The offshore transfer of coal and ores appears to be technically feasible through the use of slurry transfer methods. However, the transfer of grain over a considerable distance from an offshore area would pose significantly greater problems. Alternatives have been demonstrated for the shipment of two deep-draft cargoes and further efforts are warranted.

A second major area of concern is the impact of such alternatives to dredging on an inshore port areas' economy. From a regional viewpoint it might be argued that the shifting of a

major portion of waterborne commerce to offshore areas merely represents a relocation of economic benefits. Under this circumstance, the economies of scale of bulk shipment offshore terminals would benefit the regional economy. On the other hand, it might be held that the concentration of commerce at a few offshore terminals would reduce some of the local multiplier effects and lower regional employment and revenues would result. These uncertainties must be resolved prior to the promotion of a regional dredging plan for offshore terminals.

CHAPTER 6

Conclusions and Recommendations

The United States is faced with an average increase of 55% over the next decade of the volume of material that will need to be dredged from the nation's waterways. The majority of this future dredging work will be devoted to navigational projects in support of the waterborne transport of cargo. In the past five years, dredging has become an increasingly expensive and environmentally controversial operation. In view of the significantly larger volumes of material to be dredged in the future, this expense and controversy can be expected to neighten. It was the intent of this effort to identify and develop alternatives to the continued dredging of waterways. This goal was not achieved. However, alternatives to the shipment of some waterborne cargoes which do not require dredging have been identified and defined. This is considered an interim step towards the stated goal. A regional or national policy which promotes the transit of major deep-draft cargoes by means other than dredged channels will achieve this goal. The scope of the present effort originally encompassed the waterways of the Gulf Coast region dredged to greater than 15 feet. The subsequent development of an offshore petroleum product terminal includes those waterways from the Passes of the Mississippi River West to the Matagorda Ship Channel in Texas. The following is concluded:

1. For the majority of the Region's waterways, there is evidence to suggest that present project depths support the commerce of only a minimum number of

cargoes. In particular shipments of Grain, Ore, Crude Oil and Petroleum Products overall account for 70% of the total ocean-going tonnage.

2. If alternatives to dredged channel shipment of a minimum number of cargoes are developed, project depths may be reduced on some waterways with a resulting savings to the Federal dredging budget.
3. Local shipment and receipt information is required in addition to published water-commerce statistics to identify those cargoes shipped routinely in deeper draft vessels.
4. The extent of savings resulting from a reduction in waterway project depth cannot be determined from routinely published dredging statistics. This information may be deduced from a data bank of past dredging operations assembled by Arthur D. Little, Inc. in support of reference 25.
5. There is ample evidence to suggest that the economies of deepwater crude oil terminals uphold the concept of such an offshore terminal as a viable alternative to dredged channel transport of this cargo.
6. There is sufficient evidence to suggest that an offshore deepwater petroleum product terminal appears to be a viable alternative to dredged channel transport of these cargoes.
7. The shifting of waterborne commerce from inshore ports areas to offshore transfer sites would be

strongly resisted by inshore port area interests.

8. The economic success of offshore cargo terminals appears to be extremely sensitive to the level of throughput initially attained at these facilities. Initial throughputs may be guaranteed through advance contractural commitments for service. However, such commitments may not be easily attained if strong opposition is voiced by inshore port area interests.
9. If alternatives to dredged channel shipment of cargoes are developed, the reduction of project depths may be used as an incentive for the use of such alternatives.

There are several areas that were not covered in depth in the conceptual design of a deepwater petroleum product terminal. Additionally, some assumptions were based on the "best available information" but need be investigated thoroughly in a more detailed effort. With these limitations of the present work in mind, the following recommendations are proposed:

1. The petroleum transport costs curves of Reference 14 were used in the computation of transport savings of offshore terminals. These costs must be verified and/or adjusted for the particular receiving port capabilities. A 70K DWT tanker lightened to gain entrance to a receiving harbor will not exhibit the same costs as when fully laden.
2. Offshore terminals in addition to competing with inshore port areas will need to compete with foreign

transshipment centers. At present there are three such facilities in Cadada and three in the Caribbean all of which are presently supplying U. S. markets. Additionally, there has been a movement by some Persian Gulf countries toward extensive expansion of their refining capabilities. All of these factors could introduce more uncertainty into the throughputs to be attained by U. S. offshore terminals. The potentional danger of the failure to meet design throughput cannot be overemphasized. A mere 6% reduction from design throughput drives the net present value of the proposed SEADOCK crude oil facility from 130M to a negative $20M. (See Appendix D.) Should SEADOCK choose to raise its handling tariff to realize the initial 15% return on investment, its competitive position with foreign transshipment facilities will be degraded. The impact of these uncertainties must be gauged in a more detailed design effort.

3. The costs of delivering petroleum products to the tank farms of an offshore product terminal have not been fully addressed. The competitive position of such an offshore facility is determined by the cumulative costs of a product just prior to unloading at the receiving post area. This cumulative cost would be the sum of f.o.b. cost at the refinery, the delivery cost to the offshore facility, the tariff of

the offshore facility, and the tanker transportation costs. With the f.o.b. costs of the refinery the same for all transport modes, the costs of delivery to an offshore facility is the remaining uncertain element. This cost has not been addressed because of its dependence on local conditions. There is a high degree of flexibility in the conversion of crude oil pipelines to product lines and vice versa. The same may be said of barge transport of these cargoes. A very low delivery cost may result if in the maze of pipelines transversing the Gulf Region product lines exist or may be converted within a short distance of the facility. If rights of way must be purchased to facilitate the laying on new lines, a high delivery cost may result. In either event these costs must be investigated early in a detailed design effort.

4. The question of the net regional and national economic impact from the benefits of an offshore terminal in combination with the probable losses to local inshore port areas must be assessed. Offshore deepwater terminals have laid claim to economies of scale in ocean transport costs while inshore port areas boast of the multiplier effect that commerce produces in local revenues and employment. If serious consideration is to be given to the movement of major cargoes from

inshore to an offshore transfer environment, the assessment of this question is basic to any public policy decision.

5. The civil or national defensability of a system or complex of offshore deepwater terminals has not been addressed and needs to be investigated.
6. The transit requirements of non-cargo carrying vessels and water service facilities such as passenger vessels and shipbuilding yards have not been investigated. The impact of a change in dredging policy must be assessed on the transit needs of these waterway users.

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APPENDIX A

FEDERAL DREDGING PROGRAM DATA BASE

(1964-1983)

The data base used for the analysis of the Federal Dredging Program in Chapter 3 was obtained (except where otherwise indicated) from The National Dredging Study (25) recently completed for the Corps of Engineers by A. D. Little, Inc. This study compiled information on past dredging and future estimates of dredging requirements from the Corps' thirty-eight district offices. Several of the figures presented in Chapter 3 were excerpted from this study, as indicated, the remainder were constructed from the data presented in Table A-1 that follows:

TABLE A-1

FEDERAL DREDGING PROGRAM STATISTICS

FISCAL YEAR	TOTAL VOLUME DREDGED (M CY)	TOTAL COSTS ($'s millions) CURRENT $'s	1964 GNP $'s	1972 GNP $'s	UNIT COST $ (1972/CY)
1964		138	138	184	
1965		149	146	195	
1966		150	144	192	
1967		119	111	148	
1968	339	123	111	148	0.44
1969	343	129	111	148	0.43
1970	395	133	109	145	0.37
1971	361	149	115	154	0.43
1972	351	139	104	139	0.39
1973	381	168	120	159	0.42
SOURCE	A	B	B	DERIVED	DERIVED
		1973 GNP $'s		1972 GNP $'s	
1974	423	229		193	0.45
1975	480	312		265	0.55
1976	496	328		269	0.54
1977	496	325		261	0.53
1978	586	402		342	0.58
1979	674	419		354	0.53
1980	592	384		324	0.54
1981	588	363		307	0.52
1982	602	338		288	0.47
1983	589	315		278	0.47
TOTAL	5526	3415		2881	
SOURCE	C	C		DERIVED	DERIVED

TABLE A-1 (cont'd)

NEW WORK

FISCAL YEAR	VOLUME (M.CY)	COST (1964) (M $'s)	COST (1972) (M $'s)	$ (1972) /CY
1964				
1965				
1966				
1967				
1968	89	42	56	0.62
1969	109	45	60	0.55
1970	89	31	41	0.46
1971	83	38	51	0.61
1972	68	27	36	0.52
1973	73	37	49	0.67
Sources	A	B	Derived	Derived

MAINTENANCE WORK

FISCAL YEAR	VOLUME (M.CY)	COST (1964) (M $'s)	COST (1972) (M $'s)	$ (1972/ CY
1964				
1965				
1966				
1967				
1968	250	69	92	0.37
1969	234	64	86	0.37
1970	306	76	101	0.33
1971	278	76	102	0.37
1972	283	77	102	0.36
1973	308	83	111	0.36
Source	A	B	Derived	Derived

SOURCES:
A - <u>National Dredging Study</u>, Table VI-3, p. VI-8
B - <u>National Dredging Study</u>, Table VI-4, p. VI-10
C - <u>National Dredging Study</u>, Table IV-60, p. IV-144

APPENDIX B

GULF COAST WATERWAYS

WITH NAVIGATIONAL DEPTHS EXCEEDING 15 FT.

		CONTROLLING DEPTH OF ENTRANCE (FT.)	PROJECT DEPTH (FT.)
I. JACKSONVILLE DISTRICT			
1)	St. Petersburg Harbor,Fla.	19'	20'
2)	Tampa Harbor, Fla.	36'	36'
3)	Weedon Island, Fla.	33'	Non-Federal
II. MOBILE DISTRICT			
4)	Port St. Joe Harbor, Fla.	37'	37'
5)	Panama City Harbor, Fla.	30'	34'
6)	Pensacola Harbor, Fla.	35'	35'
7)	Mobile Harbor, Ala.	41'	42'
7a)	Three Mile Creek, Ala.	30'	State of Ala.
7b)	Chicksaw Creek, Ala.	23'	25'
8)	Pascagoula Harbor, Miss.	40'	40'
8a)	Bayou Casotte, Miss.	38'	38'
9)	Gulfport Harbor, Miss.	28'	32'
III. NEW ORLEANS DISTRICT			
10)	Mississippi River Gulf Outlet, La.	35'	38'
11)	Baton Rouge, La.	40'	40'
12)	Mississippi River, Baton Rouge, La., to but not including New Orleans, La.	40'	40'
13)	New Orleans, La.	40'	40'
13a)	Inner Harbor Navigation Canal, La.	28'	32'
14)	Mississippi River, New Orleans, La., to mouth of passes	40'	40'
15)	Mississippi River Passes,La.	23/36'	20/40'
16)	Atchafalaya River, La. Morgan City to Gulf of Mexico	17'	20'
17)	Calcasieu River and Pass, La. (Lake Charles, La.)	40'	42'
IV. GALVESTON DISTRICT			
18)	Sabine - Neches Waterway,Tex.	38'	42'
18a)	Orange, Tex.	30'	30
18b)	Beaumont, Tex.	40'	40'
18c)	Port Arthur, Tex.	41'	40'
18d)	Sabine Pass Harbor, Tex.	38'	40'

APPENDIX B (con't)

		CONTROLLING DEPTH OF ENTRANCE (FT.)	PROJECT DEPTH (FT.)
19)	Houston Ship Channel, Tex.	36'	40'
20)	Texas City Channel, Tex.	38'	40'
21)	Galveston Harbor, Tex.	40'	42'
21a)	Galveston Channel, Tex.	40'	42'
22)	Freeport Harbor, Tex.	34'	47
23)	Matagorda Ship Channel, Tex.	35'	38'
24)	Corpus Christi Ship Channel, Tex.	46'	47'
25)	Harbor Island, Tex.	46'	47'
26)	Corpus Christi, Tex.	37.5'	45'
27)	Brazos Island Harbor, Tex.	38'	38'
27a)	Brownsville, Tex.	38'	38'
27b)	Port Isabel, Tex.	36'	36'

Source: WATERBORNE COMMERCE, 1974

APPENDIX C

DESIGN CALCULATIONS FOR AN OFFSHORE DEEPWATER PETROLEUM PRODUCT TERMINAL

This Appendix details the following calculations necessary for the design and evaluation of an offshore deepwater petroleum product terminal.

1. Construction cost estimates.
2. Assumptions for Net Present Value Analysis
3. Net Present Value Analysis

TABLE C-1. Calcasieu Shoaling and Dredging Frequency

TABLE C-2. Projected Maintenance Dredging Quantities and Costs (1973) on Selected Waterways in the New Orleans District (1974-1983).

TABLE C-3. Allotments for Maintenance Dredging of Selected Gulf Coast Waterways.

TABLE C-4. National NPV of an Offshore Petroleum Product Terminal.

TABLE C-5. NPV to an Operator of an Offshore Petroleum Product Terminal.

1. <u>Construction Cost Estimates for an Offshore Deepwater Petroleum Product Terminal</u>

A. LOOP AREA:

1. Terminal:

<u>Description</u> - 10 mi. offshore Bayou LaFourche
60 ft. of water
Fixed pier - to facilitate multi-product shipments
To ship: Gasoline, Jet Fuel, Kerosene and Distillate Fuel Oil.

<u>Throughput</u> - (1974) 350K B/D grow at 2.5%/yr. compounded to 1980 with current growth in demand for petroleum products

initial - (1980) 400K B/D grow at 2.0%/yr. through 2000 then at 1.0%/yr. through 2004
- (1985) 440K B/D
- (1990) 480K B/D
- (2000) 590K B/D

ultimate - (2004) 620K B/D

<u>Berthing Requirement</u>: (Average petroleum product=8.0 BBL/ long ton)

(1) 70K DWT = 560,000 BBL/Tanker
(1) 60K DWT = 480,000 BBL/Tanker
(1) 50K DWT = 400,000 BBL/Tanker

With an average loading rate of 40K BBL/hr., (based on Northville Industries' product terminal on L. I., N.Y. and at Bonaire, N.A.) (34), one tanker per day will maintain throughput through 1990 after which two tankers per day will be required. Therefore, for initial configuration:

1980 - (1) berth for 50K DWT tankers
1990 - (2) berth for 60K DWT tankers
2000 - (2) berth for 70K DWT tankers

If warranted may upgrade to 70K DWT tankers at a faster pace. Do not believe initial design for 70K DWT tankers

is warranted. Very few coastal ports on PAD I (i.e., E. Coast) are capable of receiving greater than 50K DWT tankers fully loaded. A survey of Drewry Shipping and Shipping Statistics for 7/74 thru 6/75 revealed that on average world-wide shipments of "clean" petroleum (i.e., products) are carried in 35K - 45K DWT tankers. One intra-Caribbean shipment in a 80K DWT tanker was noted.

Cost Estimate: Terminal = $35M

(Cost of Northville Long Island product terminal 1970 = $10M, 1/2 mile from shore.)(34)

Cost of proposed crude oil fixed platforms by MASSPORT (1973) = $25M, 10 miles offshore. (32)

Added berth and capacity of terminal in 1990 = $9M.

2. Submarine Pipeline:

The following unit costs for the construction of submarine pipelines were utilized from estimates provided in the Oil and Gas Journal (8/18/75 V. 73, N. 33), SEADOCK's application and The Challenge of Deepwater Terminals:

All dimensions are for outer diameter (O.D.)

8" = $200 K/mi	30" = $600 K/mi
12" = $230 K/mi	36" = $800 K/mi
16" = $270 K/mi	40" = $982 K/mi
20" = $320 K/mi	48" = $1690 K/mi
24" = $390 K/mi	52" = $2400 K/mi

Cost Estimate:

Gasoline, Jet Fuel, Kerosene	- (1) 30"x 10 mi. x $600K/mi.=$6M
Distillate Fuel Oil	- (1) 8"x 10 mi. x $600K/mi.=$6M
Bunker/Ballast (return)	- (1) 8"x 10 mi. x $200K/mi.=$2M

Add (1990) (1) 30"x 10 mi. x $600K/mi. x 1.33=$8M

3. Onshore Storage

Description - storage of 500K B/D for 7 days
floating roof type tanks
tank capacity = 800K BBL each
initial storage capacity = 3.5M BBL
4 tanks initially
2 tanks added 1990

Cost Estimate:

Onshore storage costs include land, rights of way, piping buildings, etc. Costs will vary widely with locale. No breakdown is given in LOOP application, therefore, an estimate of \$6M/tank including all of the above factors was used as derived from the SEADOCK application.

Initial cost = 4 tanks x \$6M/tank = \$24M

Added cost (1990) = 2 tanks x \$6M/tank x 1.33 = \$16M

4. Distribution pipeline

Distribution pipeline is estimated to provide for product receipt from two major refining areas, i.e., from Mississippi River Baton Rouge, La. to New Orleans ("The Petroleum Gold Coast"), and the Mississippi Delta Region near Venice, La.

Unit Costs

The following unit costs for onshore piping were developed from the Oil and Gas Journal, SEADOCK application and The Challenge of Deepwater Terminals.

6" = \$8 K/mi	20" = \$114 K/mi
8" = \$20 K/mi	24" = \$148 K/mi
10" = \$30 K/mi	30" = \$200 K/mi
12" = \$45 K/mi	36" = \$240 K/mi
14" = \$100 K/mi	48" = \$320 K/mi
16" = \$106 K/mi	

These unit costs include rights of way, material, labor, and booster pumps.

Cost Estimates:

a. From upper Mississippi River

Gasoline & Jet Fuel - (1) 10"x$30K/mi.x75 mi.=$2.25M
Kerosene - (1) 6"x$ 8K/mi.x75 mi.=$6M
Distillate Fuel Oil - (1) 8"x$20K/mi.x75 mi.=$1.5M

Sub Total $5M

b. From lower Mississippi River

Gasoline, Jet Fuel - (1) 10"x50x50=$2.5M
Kerosene - (1) 6"x 8x50=$ .6M
Distillate Fuel Oil - (1) 8"x30x50=$1.5M

Sub Total $5M
TOTAL $10M

5. Organization Costs: As estimated by SEADOCK, INC. = approximately 15% of construction costs

Construction costs (less distribution piping) = $73M

Organization costs = .5x$73M = $11M

Added organization cost (1990) = $5M

6. Total Facility Costs:

Construction	=	$73M	
Organization	=	$11M	
(1980) TOTAL	=	$84M	(w/o distribution)
		$94M	(w/distribution)
1990 Additional=		$38M	

B. SEADOCK AREA

1. Terminal:

Description - 10 mi. offshore Freeport, Tex.
- 60 ft. of water
- Fixed pier
- To ship: Gasoline, Jet Fuel, Kerosene and Distillate Fuel Oil

Throughput:

initial (1974) - 660K B/D

(1980)=700K B/D	ultimate	(2000)=1040K B/D
(1985)=770K B/D		(2004)=1090K B/D
(1990)=850K B/D		

Berthing Requirements

Pumping rate: initial - 40K BBL/hr. (1980)
ultimate - 80K BBL/hr (1990)
(1980) - (2) berth for 50K DWT tanker
(1990) - (2) berth for 60K DWT tanker
(2000) - (2) berth for 70K DWT tanker

Cost Estimate:

Terminal = $40M based on LOOP area terminal estimate with $5M additional for second berth in 1980.
Upgrade capacity only in 1990 = $11M

2. Submarine Pipelines;

Cost Estimate: Using unit cost, developed from Part A-2:

Gasoline, Kerosene, Jet Fuel - (1) 36"x10 mi.x$800K/mi.=$8M
Distillate - (1) 36"x10 mi.x$800K/mi.=$8M
Bunker/Ballast (return) - (1) 8"x10 mi.x$200K/mi.=$2M

Add (1990) - (1) 36"x10 mi.x$800/Kmi.x1.33=$9M

3. Onshore Storage

Description - storage for 800K B/D for 7 days
floating roof tanks
tank capacity=800K BBL each
initial storage capacity=5.6M BBL
initally 7 tanks
3 tanks added in 1990

Cost Estimate: As developed in Part A-3:

Initial cost (1980) = 7 tanks x $6M/tank =$42M

Added cost (1990) = 3 tanks x $6M/tank x 1.33 = $24M

4. Distribution piping: Product will be received from the following refinery centers: Houston, Galveston/Texas City, Sabine-Neches, and Lake Charles.

Unit Costs - As developed in Part A-4

Cost Estimate:

a. from Houston refineries:

Gasoline and Jet Fuel - (1) 10"x$30K/mi.x60 mi.=$1.8M
Kerosene - (1) 8"x$20K/mi.x60 mi.=$1.2M
Distillate Fuel Oil - (1) 12"x$45K/mi.x60 mi.=$2.7M

Sub Total =$5.7M

b. from Galveston/Texas City:

Gasoline and Jet Fuel - (1) 20"x$114K/mi.x40 mi.=$4.6M
Kerosene - (1) 14"x$100K/mi.x40 mi.=$4M
Distillate Fuel Oil - (1) 16"x$85K/mi. x40 mi.=$3.4M

Sub Total = $12M

c. from Sabine-Neches via Galveston/Texas City:

Gasoline and Jet Fuel - (1) 14"x100x75=$7.5M
Kerosene - (1) 10"x 30x75=$2.25M
Distillate Fuel Oil - (1) 12"x 45x75=$3.4M

Sub Total =$13M

d. from Lake Charles via Sabine-Neches:

Gasoline and Jet Fuel - (1) 10"x 30x35=$1M
Kerosene - (1) 6"x 8 x35=$.3M
Distillate Fuel Oil - (1) 8"x 20x35=$.7M

Sub Total =$2M

TOTAL DISTRIBUTION =$32.7M

5. <u>Organization Costs</u>: as per Part A-5

Construction cost (less distribution) = $100M
Organization costs = .15x$100M=$15M
Added Organization costs (1990) = $6M

6. <u>Total Facility Cost</u>

Construction = $100M
Organization = $15M
(1980) Total = $115M (w/o distribution)
= $148M (w/distribution)
1990 Additional = $50M

2. <u>Assumptions for Net Present Value Analysis</u>

Values used in NPV computations for Tables C-4 and C-5 were derived as follows:

A. Annual Maintenance Cost:

The deepwater port study for MASSPORT (32) reports the following average maintenance estimates for a facility:

SPM	= 3% of first construction cost
Fixed Pier	= 1% of first construction cost
Tank Form	= 2% of first construction cost
Onshore pipelines	= 0.5% of first construction cost
Submarine pipelines	= 1% of first construction cost

MASSPORTS' alternatives for a fixed pier terminal show that total maintenance costs amounted to 1.5% of total initial investment. These estimates were found in agreement with those of SEADOCK's application which represented 1.5% of the total initial construction costs and a compounded growth of 5%/yr. after 5 years of operation.

Therefore, it will be assumed for this analysis:

Maintenance cost = 1.5% of total initial investment and compounded growth of 5%/yr.

B. Operating Costs

Two references were found which contained operating cost information for deepwater port terminals, the estimates performed for MASSPORT (32) provided annual operating cost but did not include insurance and tax estimate. SEADOCK's application contains relatively detailed operating costs estimates and these were therefore chosen.

Operating Cost = 3.5% of total initial investment and growth of 4.5%/yr.

C. Transport Savings:

As derived from Figure 5.2 for a 50K, 60K, and 70K DWT tanker with a route length of 1500 s. miles as compared

to the transport costs for 30K DWT tanker on the same route These savings are understated in that the DWT tonnage was assumed to be equal to the carrying capacity of the vessel.

D. Discount rate:

A discount rate for the Net Present Values calculation of 12% was assumed. SEADOCK had used 10% as their discount rate for the offshore crude oil port.

E. Dredging Savings:

Savings may be realized in the Federal Dredging Budget in two ways. The cost of future new work dredging requests (as in Table 3.1) to further deepen existing waterways may be avoided by the provision of offshore deepwater transport facilities. These savings are considered strictly potential, uncommited in some cases and will not be considered in the NPV analysis of offshore product terminals. A second manner of dredging savings might result from a reduction in funds presently commited to the maintenance dredging of ocean-going waterways within the influence areas of offshore deep-water terminals. A public policy decision to reduce the project depths on these waterways would directly result in savings in the cost of maintenance dredging. These latter savings will be accounted for in the national NVP analysis. If project depths were to be reduced on the waterways, maintenance dredging could be stopped and waterways allowed to snoal up to their newly authorized depths. Ideally a shoaling" model might be constructed to compute:

1. The time required for the waterways to reach the new depths in which maintenance expenditures would be avoided.

2. The new volume of maintenance dredging required with waterways at their reduced Project Depths.

Such a model exists at the Corps' Vicksburg, Mississippi Experiment Station but only for the Mississippi River system. The magnitude of savings realized is dependent upon how quickly a waterway deposits sediment (shoaling rate) and also the change in shoaling rate with project depth. Shoaling rates over a narrow range of depths have been computed for some of the major waterways within the New Orleans district. Shoaling rates for the Calcasieu River and Pass, La. as computed by the Corps' New Orleans District are shown in Table C-1. It is noted that the range of these rates may be considerable between waterways as well as on sections of a single waterway. In addition to many other factors, shoaling is strongly dependent upon current flow. As a project depth is allowed to rise over a section of waterway, current flows might be expected to increase causing a decrease in the shoaling rate. Therefore, a further reduction in maintenance dredging requirements might result at a lower project depth. Shoaling rates are not available for all the ocean-going waterways within the influence areas of LOOP and SEADOCK. The change in shoaling rates with project depth on these waterways is speculative. The following approximations are made to compute dredging savings.

1. An average shoaling rate for the waterways within the influence areas of the offshore product terminals of 0.2 ft/month is assumed. (Approximately equals average rate of Table C-1.)

TABLE C-1

CALCASIEU SHOALING AND DREDGE FREQUENCY

The following shoaling rates for Calcasieu River and Pass are predicted using contract and hopper pay yardage and frequency of dredging from 1969 to 1973:

Location	Shoaling Feet/Month	Dredging Frequency
Mile 36.0 to Mile 34.0	0.15	4 yrs.
Mile 34.0 to Mile 15.5	0.20	2 yrs.
Mile 15.5 to Mile 5.0	0.30	2 yrs.
Mile 5.0 to Mile -1.5	0.02	10 yrs.
Mile -1.5 to Mile-10.0	0.50	1 yr.
Mile -10.0 to Mile-15.0	0.30	2 yrs.
Mile -15.0 to Mile-19.0	0.16	4 yrs.
Mile -19.0 to Mile-24.0	0.03	8 yrs.
Clooney Island Loop Mile 33.8	0.15	4 yrs.
Coon Island vicinity Mile 32.0	0.15	4 yrs.
Devil's Swamp vic. Mile 22.5	0.15	4 yrs.
Channel to Cameron Mile 2.2	0.22	2 yrs.
AVERAGE =	.21ft./month	

The following depths are required to maintain the -35 foot MLG channel from mile 36.0 to mile 24.0, the -40 foot MLG channel from mile 34.0 to mile 0.0 and -42 foot MLG channel in the gulf entrance channel:

Location	Required Depth	Allowable Overdepth
Mile 36.0 to Mile 34.0	-36 MLG	+1 foot
Mile 34.0 to Mile -1.5	-41 MLG	+1 foot
Mile -1.5 to Mile-24.0	-42 MLG	+3 feet
Clooney Island Loop Mile 33.8	-42 MLG	+2 feet
Coon Island vicinity Mile 32.0	-42 MLG	+2 feet
Devil's Swamp vic. Mile 22.5	-41 MLG	+1 foot
Channel to Cameron Mile 2.2	-14 MLG	+2 feet

NOTE: MLG stands for Mean Low Gulf

Source: New Orleans
Corps of Engineers
District-Dredging
Operations Division (35)

2. It is assumed that all waterways have been dredged to a 2 ft. overdepth in excess of project depth when maintenance dredging is ceased. Maintenance dredging will commence again when controlling depths exceeds project depth.

3. With the previous assumptions a 3 ft. reduction in project depth will allow maintenance dredging to cease for approximately 2 years. Dredging may be halted for a period of 4 years with a depth reduction of 7 ft.

4. Shoaling rates will be assumed to remain constant over the range of project depths considered.

With these assumptions yearly dredging maintenance costs are avoided for a 2 or 4-year period and then resumed at their initial levels. Table C-2 is a portion of the data submitted by the Corps' New Orleans District A. D. Little, Inc. for the National Dredging Study. (25) The costs (1973) of the projected annual maintenance dredging for the LOOP area waterways is \$9.77M/yr. This cost compares favorably with the allotments for 1973 recorded for these same waterways in Appendix 5.1 of Federal Port Policy in the United States. (20) If a compounded rate of inflation of 5%/yr. is assumed for the cost of dredging, the 1980 cost of maintenance dredging for the LOOP area waterways is \$13.1M/yr. Projected maintenance dredging cost estimates for the waterways within the SEADOCK area of the Corps' Galveston district are unavailable. (A. D. Little, Inc. reports that the magnetic tape containing this information was inadvertently destroyed.) Since Federal Port Policy estimates were found in agreement with those of the LOOP area waterways, the allotment estimates shown in

TABLE C-2

Projected Maintenance Dredging Quantities and Costs (1973) on Selected Waterways in the New Orleans District (1974- 1983)

SECTION OF WATERWAY	FREQUENCY OF DREDGING	QUANTITY (CY's M)	UNIT COST ($/CY)	1973 COST ($'s M)
Baton Rouge Harbor	Annual	0.175	0.98	0.172
Mississippi River, Baton Rouge to New Orleans	Annual	5.43	0.23	1.267
New Orleans Harbor	Annual	3.70	0.28	1.04
Mississippi River - South West Pass	Annual	7.0	0.27	1.89
Mississippi River - South Pass	Annual	3.4	0.29	0.97
Mississippi River - Bar Channel (S. & S.W. Passes)	Annual	10.0	0.20	2.00
Mississippi River - Gulf Outlet : Land Cut	Annual	11.57	0.21	2.43
TOTAL		41.28		9.77

Source: Estimates Prepared by Army Corps of Engineers New Orleans District for A.D. Little, Inc. (35)

Table C-3 will be used for the SEADOCK area. Inflating the 1973 estimate of $7.7M/yr. by 5%/yr. the 1980 projected cost of maintenance dredging within the SEADOCK area is $10.4M.

Dredging savings are computed as follows for a discount rate of 12%:

1. LOOP AREA

   a. with no reduction in P.D. -$13.1M/yr. for 25 yrs:
      P.V. = -$102.7M

   b. with a 3 ft. reduction in P.D. -$0M for first 2 yrs. and $-13.1M/yr. for next 23 yrs.:

      P.V. - $80.6M
      NPV Savings (3 ft.) = $22M
      Annual equivalent = $2.8M/yr.

   c. with a 7 ft. reduction in P.D. -$0M for first 4 years and -$13.1M/yr. for next 21 yrs.:

      P.V. - $62.9M
      NPV savings (7 ft.) = $39.8M
      Annual equivalent = $5.07M/yr.

2. SEADOCK AREA

   a. with no reduction in P.D. -$10.4M/yr. for 25 yrs.
      P.V. - $81.6M

   b. with a 3 ft. reduction in P.D. -$0M/yr. for first 2 yrs. then -$10.4M/yr. for next 23 yrs.:

      P.V. = -$64M
      NPV of (3 ft.) = $17.6M
      Annual equivalent = $2.25M/yr.

   c. with a 7 ft. reduction in P.D. -$0M for first 4 yrs. then $-10.4M/yr. for next 21 yrs.:

      P.V. = -$50M
      NPV of (7 ft.) = $31.6M
      Annual equivalent = $4.03M/yr.

F. Interest:

Interest costs were based upon an 8%/yr. interest rate amortized over 25-year life cycle of the facility.

TABLE C-3

Allotments for Maintenance Dredging of Selected Gulf Coast Waterways

$(1,000's)

WATERWAY	1970	1971	1972	1973
LOUISIANA				
Mississippi River - Passes to Baton Rouge, La.	6,325.0	4,626.1	6,057.3	6,000.0
Mississippi River - Gulf Outlet	8,814.0	1,915.5	3,373.5	3,500.0
TOTAL	15,139.0	6,541.6	9,430.8	9,500.0
TEXAS				
Freeport Harbor and Channel	525.1	737.1	573.0	400.0
Galveston Harbor and Channel	530.1	1,137.0	1,503.2	1,225.0
Houston Ship Channel	2,286.9	1,564.0	1,851.5	2,300.0
Matagorda Ship Channel	1,428.0	338.5	1,087.2	1,100.0
Sabine- Neches Waterway	1,840.0	2,794.0	2,617.9	2,700.0
Texas City Channel	523.0		693.7	
TOTAL	7,133.1	6,570.6	8,326.5	7,725.0

Source: Appendix 5.1 of Federal Port Policy in the United States. (20)

G. Depreciation:

A Straight-Line method of depreciation was used over the 25-year period with 10% of initial value allowed for salvage value in year 2004. Depreciation was included for the return on asset calculations only and does not enter into the NPV calculations.

3. Net Present Value Analysis for an Offshore Deepwater Petroleum Product Terminal

Based upon the assumptions in the previous two sections, the NPV of an offshore deepwater petroleum product terminal has been carried out in the following tables. The Net Present Value of a project is defined as:

$$NPV = \sum_{t=0}^{n} A_t/(1+r)^t$$

Where r is the discount rate, n is the life cycle for a project and A_t is the net cash flow or benefits for a project during a particular time period t. The net national benefits for the present product terminals are equal to the transport and dredging savings less the sum of the construction and distribution piping investment, maintenance, and operational costs. The net benefits to an operator, similarly are equal to the gross revenues less the sum of construction investment, maintenance, operational, and interest costs. Transport savings have been calculated with both terminals serving 50K DWT tankers from 1980 through 1989, 60K DWT tankers from 1990 through 1999 and 70K DWT tankers after the year 2000.

TABLE C-4a

National NPV of an Offshore Petroleum Product Terminal

LOOP Area

($'s millions)

COSTS	1980	1985	1990	2000	2004
Throughput (1,000 B/D)	400	445	490	600	625
Investment (less distribution piping)	-84		-38		
Maintenance	-1.3	-1.6	-2.1	-3.3	-4.3
Operational	-2.9	-3.7	-4.6	-7.1	-8.8
Total Direct Operational	-84/-4.2	-5.3	-38/-6.7	-10.4	-13.1
Transport Savings	14.6	16.2	23.3	37.2	38.8
Cash Flows	-84/10.4	10.9	-38/16.6	26.8	25.7
NPV	5.1				
NPV including cost of distribution piping (1980)	-4.9				
NPV including distribution piping and a 3 ft. reduction in project depths	17.1				
NPV including distribution piping and a 7 ft. reduction in project depths	34.9				

TABLE C-4b

National NPV of an Offshore Petroleum Product Terminal

SEADOCK Area

($'s millions)

COSTS	1980	1985	1990	2000	2004
Throughput (1,000 B/D)	700	770	850	1040	1090
Investment (less distribution piping)	-115		-50		
Maintenance	-1.7	-2.2	-2.8	-4.6	-4.9
Operational	-4.0	-5.0	-6.3	-9.7	-12.0
Total Direct Operational	-115/-5.7	-7.2	-50/-9.1	-14.3	-16.9
Transport Savings	25.6	28.1	40.3	64.5	67.6
Cash Flow	-115/19.9	20.9	-50/31.2	50.2	50.9
NPV	60.7				
NPV including cost of distribution piping (1980)	28.0				
NPV including distribution piping and a 3 ft. reduction in project depths	45.6				
NPV including distribution piping and a 7 ft. reduction in project depths	59.6				

TABLE C-5a

NPV to an Operator of an Offshore Petroleum Product Terminal - LOOP Area

($'s millions)

COSTS	1980	1985	1990	2000	2004
Throughput (1,000 B/D)	400	445	490	600	625
Investment (less distribution piping)	-85		-38		
Tariff ($/BBL)	0.18	0.16	0.15	0.14	0.10
Gross Revenue	26.3	26.0	26.8	30.7	22.8
Maintenance	- 1.3	-1.6	-2.1	-3.3	-4.3
Operational	-2.9	-3.7	-4.6	-7.1	-8.8
Total Direct Operational	-84/-4.2	-5.3	-38/-6.7	-10.4	-13.1
Interest	-6.7	-5.9	-4.6	-2.0	-
Depreciation	-2.6	-2.6	-4.7	-4.5	-
Total Operating Cost	-13.5	-13.8	-16.0	-16.9	-13.1
Net Cash Flow (less depreciation)	-84/15.4	14.8	-38/15.5	18.3	9.7
NPV	25.0				

TABLE C-5b

NPV to an Operator of an Offshore Petroleum

Product Terminal - SEADOCK Area

($'s millions)

COST	1980	1985	1990	2000	2004
Throughput (1,000 B/D)	700	770	850	1040	1090
Investment (less distribution piping)	-115		- 50		
Tariff ($/BBL)	0.14	0.13	0.12	0.11	0.09
Gross Revenue	35.8	36.5	37.2	41.8	35.8
Maintenance	- 1.7	- 2.2	- 2.8	-4.6	-4.9
Operational	-4.0	-5.0	-6.3	- 9.7	-12.0
Total Direct Operational	-115/-5.7	- 7.2	-50/-9.1	-14.3	-16.9
Interest	-9.2	- 8.1	-6.3	-2.7	-
Depreciation	-3.6	- 3.6	-6.2	-6.2	-
Total Operating Cost	-115/-18.5	-18.9	-50/-21.6	-23.2	-16.9
Net Cash Flow (less depreciation)	-115/20.9	21.2	-50/21.8	24.8	18.9
NPV	37.6				

APPENDIX D

SENSITIVITY ANALYSIS CALCULATIONS

The change in the national NPV of an offshore deepwater petroleum product terminal in the SEADOCK area with changes in the costs and savings estimates of Appendix C is examined in this Appendix. The change in the NPV of the SEADOCK proposal to the operator with a change in design throughput is also investigated. The following tables present the results of this analysis:

TABLE D-1. Sensitivity of the National NPV of an Offshore Petroleum Product Terminal.

TABLE D-2. Change in the NPV of SEADOCK to the Operator with Design Throughput

TABLE D-1

SENSITIVITY OF THE NATIONAL NPV OF AN OFFSHORE PETROLEUM PRODUCT TERMINAL - SEADOCK AREA

($ - Millions)

COSTS	1980	1985	1990	2000	2004
Throughput (1000 B/D)	700	700	850	1040	1090
Investments (Incl. distribution)	-147.7		-50		
Maintenance	-1.7	-2.2	-2.8	-4.6	-4.9
Operational	-4.0	-5.0	-6.3	-9.7	-12.0
Total Direct Operational	-147.7/-5.7	-7.2	-50/-9.1	-14.3	-16.9
Transport Savings	25.6	28.1	40.3	64.5	62.6
Cash Flows	-147.7/19.9	20.9	-50/31.2	50.2	50.9
1. NPV vs DISCOUNT RATE:					
a. NPV (r=12%)	28				
b. NPV (r=8%)	106.9				
c. NPV (r=16%)	-18.2				
2. NPV vs THROUGHPUT GROWTH					
a. Throughput (1%/yr.)	700	735	775	855	900
Transport Savings	25.6	26.8	36.8	53.0	55.8
Cash Flows	-147.7/19.9	19.6	-50/27.7	38.7	38.9

	1980	1985	1990	2000	2004
NPV	17.6				
b. Throughput (3%/yr.)	700	810	940	1260	1460
Transport Savings	25.6	29.6	44.6	78.2	90.6
Cash Flows	-147.7/19.9	22.4	-50/35.5	64.9	73.7
NPV	412.4				
3. <u>NPV vs TRANSPORT SAVINGS</u>					
a. Transport Savings $0.5/BBL, $0.65/BBL, $.085/BBL	12.8	14.0	20.2	32.3	33.8
Cash Flows	-147.7/7.1	6.8	-50/11.1	18.0	16.9
NPV	-96.4				
b. Transport Savings $.15/BBL, $.15/BBL, $.255/BBL	38.2	42.2	60.5	96.8	101.5
Cash Flows	-147.7/32.6	34.9	-50/51.4	82.5	84.6
NPV	147.3				
4. <u>NPV vs INITIAL THROUGHPUT</u>					
a. Throughput	350	385	425	520	550
Transport Savings	12.8	14.1	20.2	32.3	34.1
Cash Flows	-147.7/7.1	6.9	-50/11.1	18.0	17.2

	1980	1985	1990	2000	2004
NPV	-96.4				
b. Throughput	1050	1160	1280	1560	1640
Transport Savings	38.3	42.3	60.7	96.8	101.8
Cash Flows	-147.7/32.6	35.1	-50/51.6	82.4	84.9
NPV	147.3				
5. NPV vs CONSTRUCTION INVESTMENT					
a. Investment	-90.2		-25		
Maintenance	-0.9	-1.1	-1.4	-2.3	-2.9
Operational	-2.0	-2.5	-3.1	-4.8	-6.0
Cash Flows	-90.2/22.7	24.5	-25/35.8	57.4	58.7
NPV	117.3				
b. Investment	-205.2		-75		
Maintenance	-2.6	-3.3	-4.2	-6.9	-8.8
Operational	-6.0	-7.5	-9.4	-14.6	-18.1
Cash Flows	-205.2/17.0	17.3	-75/26.7	43.0	39.7
NPV	-68.1				
6. NPV vs MAINTENANCE COST					
a. Maintenance (2.25%)	-2.6	-3.3	-4.2	-6.9	-8.8

	1980	1985	1990	2000	2004
Cash Flows	-147.7/19.0	19.8	-50/29.8	47.9	46.8
NPV	16.0				
b. Maintenance (0.75%)	-0.9	-1.1	-1.4	-2.3	-2.9
Cash Flows	-147.7/20.7	22.0	-50/32.6	52.5	52.7
NPV	33.2				
7. <u>NPV vs OPERATIONAL COST</u>					
a. Operational (5.25%)	6.0	7.5	9.4	14.6	18.1
Cash Flows	-147.7/17.9	18.4	-50/28.1	45.3	44.6
NPV	5.3				
b. Operational (1.75%)	2.0	2.5	3.1	4.8	6.0
Cash Flows	-147.7/21.9	23.4	-50/34.4	56.8	56.7
NPV	45.3				
8. <u>NPV vs TANKER SIZE</u>					
Transport Savings (50K DWT tankers thru 2004)	25.6	28.1	31.0	38.0	39.8
Cash Flows	-147.7/19.9	20.9	-50/21.9	23.7	22.9
NPV	2.1				

TABLE D-2

CHANGE IN THE NPV OF SEADOCK TO THE OPERATOR

WITH DESIGN THROUGHPUT

($-Millions)

COSTS		1980	1985	1990	2000	2004
1. NPV vs INITIAL THROUGHPUT						
a. Throughput (1000 B/D)		1600	1900	2000	2000	2000
Investment	1980	-659				
	1981	-206				
Tariff ($/BBL)		0.345	0.29	0.277	0.289	0.319
Revenues		201.5	204.2	202.7	211.4	232.8
Maintenance		-23.5	-25.0	-33.1	-53.9	-87.8
Operational		-46.3	-53.8	-68.2	-107.5	-173.1
Interest		-49.8	-43.8	-34.0	-14.6	–
Net Cash Flows	1980	-659				
	1981	-206				
	1980-'84	105.4	106.6	100.5	89.3	59.7
NPV (r=10%)		130.0				
b. Throughput (1000 B/D)		1500	1740	1825	1825	1825
Revenue		188.9	184.2	184.5	192.5	212.5
Net Cash Flows	1980	-659				
	1981	-206				
	1980-'84	92.8	86.6	82.3	70.4	39.4
NPV		-20.0				

Source: SEADOCK Application (18)